Strategic Environmental Assessment in Regional Land Use Planning

Indicator System for the Assessment of Degradation of Natural Resources and Land Uses with Environmental Potential for Adaptation to Global Climate Change (LUCCA)

Approved by the Faculty of Environmental Sciences and Process Engineering at the Brandenburg University of Technology Cottbus, Germany,
for the academic degree of Dr.-Ing.

presented by

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We cannot combat climate change, but we can use all possible instruments that help us to adapt our current resource and land use, and to finally admit that there is no escape from changing our behaviour towards a strict mitigation of self-induced environmental problems.

If we miss this opportunity, Earth’s living quality might very soon significantly decrease.

Strategische Umweltprüfung in der Regionalplanung

Indikatorensystem für die Bewertung der Degradation natürlicher Ressourcen und von Flächennutzungen mit Umweltpotenzial für die Anpassung an den globalen Klimawandel (LUCCA)

Von der Fakultät für Umweltwissenschaften und Verfahrenstechnik der Brandenburgischen Technischen Universität Cottbus zur Erlangung des akademischen Grades eines Doktor-Ingenieurs genehmigte Dissertation

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Declaration

I herewith declare, that this dissertation was prepared by my own and only with the use of the cited sources. I agree with a publishing of the doctoral thesis, which has not been published before, nor been presented for a degree in this or any other university.

Verfasser- und Einverständniserklärung

Hiermit erkläre ich, die vorliegende Dissertation selbstständig und nur unter Verwendung der angegebenen Quellen angefertigt zu haben. Ich bin damit einverstanden, dass diese Dissertation der Öffentlichkeit zugänglich gemacht wird. Die Abhandlung hat keiner anderen Universität, Hochschule oder Fakultät vorgelegen. Frühere Promotionsanträge wurden nicht gestellt.

Dipl.-Ing. Hendrike Helbron

Amsterdam, November 2008

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This thesis is dedicated to my parents.

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Hendrike Helbron

Summary

Strategic Environmental Assessment in regional land use planning (here: SEA-REP) is a systematic process in Germany, which aims at an optimisation of the integration of environmental policies into decision-making at regional scale. It therefore plays an essential role for the comparison of site alternatives, and the implementation of mitigation and adaptation measures of negative effects of both regional development and climate change.

Significant findings and personal experiences gained in an INTERREG project (‘transSEA’) created a fundamental basis for this doctoral research. The main objective was to develop the ‘LUCCA’ indicator system, which is a result of an analysis of land use types, that are increasingly important for effects of global climate change, and should therefore adapt to future conditions with regional land use planning. This system was developed from current German practice of the methodological application of SEA-REP in the core assessment of site-specific impacts on the affected area and impact zone. Main objectives were to integrate spatial effects of climate change into SEA-REP, and to develop a method to make particularly the tendency of physical degradation of natural resources in a region transparent.

The research was based on a comprehensive analysis of best practice of SEA and assessment methods applied in German case studies of regional land use planning. Proposed was a a two-tiered environmental baseline- and objective-led approach of impact assessment. Its first tier is a site-specific assessment of significant impacts of regional plan designations and their alternatives. An environmental conflict analysis has the aim to apply assessment thresholds of conflict intensity for each impact factor affecting the importance of assessed components of LUCCA. Results are three classes of conflict intensity, which were determined and can be measured with the help of state indicators, impact indicators and assessment thresholds. 12 LUCCA indicators were defined in connection to regional environmental orientation objectives, environmental components, land uses and further criteria for indicator selection. The second tier is represented by an overall strategic assessment of the regional plan and its designation criteria. This assessment additionally considers positive and cumulative impacts, as well as structural alternatives.

The result of the research is a standard concept for environmental orientation objectives, guidance indicators and assessment ranges for the LUCCA indicator system. Regional environmental orientation objectives, which represent outcome values of the future state of environment, were derived from existent environmental quality objectives and environmental quality standards. For each LUCCA indicator mitigation and adaptation measures of regional planning and requirements for tiering to SEA of lower land use planning were proposed.

Recommendations for vital and critical action are addressed to competent national and regional authorities of spatial and sector planning. These involve the direct integration of concerns of climate change into SEA-REP, the regional operationalisation of environmental objectives for adaptation to climate change, an improved cooperation between spatial and sector planners concerned with the future use of land and resources, and, last but not least, an involvement of the public in the setting of regional objectives for the future state of a region’s environment.

Recommendations for the competent national and federal ministries are the integration of

substantial standards into legislation, the setting of binding standards for a stricter reduction of land consumption, the determination of clear responsibilities and activities at all planning levels, and the release of guidance for effective regional land use planning practice that enhances adaptation to climate change.

The main recommendations for European regional planning bodies are to establish regional environmental objective concepts for SEA-REP, update regional environmental data profiles, apply the SEA-REP+LUCCA indicator system, develop a tiered decision-support system, challenge conventional regional planning, improve cooperation with sector planning and involve the public in the development of adaptation strategies. A recommended adaptation task at regional planning level is the designation of strictly safeguarded priority areas with specific functions of land uses for the mitigation of negative effects of climate change. Such priority areas, which should be area-specifically defined in a regional land use map, should be linked to the implementation of binding adaptation measures in lower land use planning and at project level. An operationalisation of proposed assessment steps will be necessary for the regional-specific geographic and bio-physical conditions of the EU regions.

The thesis concludes with future research needs and an outlook on the potential future role of SEA-REP. A clear responsibility of the future tasks of SEA-REP and LUCCA was recognised as a formal driving force for adaptation of land use to effects of climate change. Improved knowledge on spatial effects of climate change and vulnerability assessments will be required for an effective revision and application of SEA-REP and LUCCA. SEA should gain further importance in a transparent and participative decision-making. Environmental concerns and the protection of LUCCA will have to gain more weight, if the significance of danger and harm, caused by effects of climate change and anthropogenic land degradation, shall be mitigated now and in the future.

Zusammenfassung

Die Strategische Umweltprüfung (SUP) in der Regionalplanung (hier: SEA-REP) ist ein systematisches Verfahren in Deutschland, das eine Optimierung der Integration von Umweltzielen in die Entscheidungsfindung auf regionaler Planungsebene zum Ziel hat. Sie spielt daher eine wesentliche Rolle im Alternativenvergleich und der Umsetzung von Vermeidungs- und Anpassungsmaßnahmen an negative Auswirkungen von sowohl regionaler Entwicklung, als auch des Klimawandels.

Bedeutende Ergebnisse und persönliche Erfahrungen, die in einem INTERREG Projekt (‘transSEA’) gewonnen wurden, bilden eine grundlegende Basis für die Dissertation. Das Ergebnis dieser Dissertation ist die Entwicklung des ‘LUCCA’ Indikatorensystems. Es ergibt sich aus einer Analyse bedeutender Flächennutzungen, deren Funktionszuweisung durch Effekte des Klimawandels an Bedeutung zunehmen wird, und die daher gezielt durch Planung anzupassen sind. Das System wird aus aktueller deutscher Praxis der methodischen Anwendung von SEA-REP in der zentralen Bewertung von flächenspezifischen Umweltauswirkungen auf die betroffene Fläche und Wirkzone entwickelt. Hauptziele sind die Integration räumlicher Auswirkungen des Klimawandels in die SEA-REP und die Entwicklung einer Methode, die insbesondere die Tendenz in einer Region hinsichtlich der physikalischen Degradation der Umweltschutzgüter transparent macht.

Die Untersuchung basiert auf einer umfangreichen Analyse von ‘best practice’ SUP Verfahren, sowie auf Bewertungsmethoden, die in deutschen Fallbeispielen der Regionalplanung angewandt wurden. Vorgeschlagen wird ein zweistufiger Ansatz zur Umweltprüfung, der sich durch einen starken Bezug zu Schutzgütern und Umweltzielen auszeichnet. Die erste Stufe bildet eine flächenspezifische Prüfung erheblicher Umweltauswirkungen durch regionalplanerische Flächenausweisungen mit ihren Alternativen. Das Ziel der Umweltkonfliktanalyse ist, für jeden Wirkfaktor, der die flächenbezogen bewertete Bedeutung von LUCCA als Umweltschutzbelang beeinträchtigt, Bewertungsmaßstäbe der Konfliktintensität anzuwenden. Ergebnisse sind drei Klassen der Konfliktintensität, die mit Hilfe von Zustandsindikatoren (‘state indicators’), Wirkungsindikatoren (‘impact indicators’) und Bewertungsmaßstäben bestimmt und gemessen werden können. 12 LUCCA Indikatoren werden in Verbindung zu regionalen Umweltorientierungszielen, Schutzbelangen, Flächennutzungen und weiteren Kriterien für die Indikatorenauswahl definiert. Die zweite Stufe wird durch eine Gesamtbewertung des Regionalplans und seine Ausweisungskriterien repräsentiert. In diesem Prüfungsschritt werden zusätzlich positive und kumulative Auswirkungen, sowie Strukturalternativen geprüft.

Das Ergebnis der Forschung ist ein standardisiertes Konzept mit ‘Umweltorientierungszielen’, Leitindikatoren und Bewertungskorridoren für das LUCCA Indikatorensystem. Umweltorientierungsziele für die regionale Planungsebene, die Ergebniswerte für den zukünftigen Zustand der Umwelt repräsentieren, werden von bestehenden Umweltqualitätszielen und Umweltqualitätsstandards abgeleitet. Für jeden LUCCA Indikator werden Vermeidungs- und Anpassungsmaßnahmen für die Regionalplanung und Anforderungen für die Abschichtung auf die untere Ebene der Flächennutzungsplanung vorgeschlagen. Eine Optimierung des Regionalplanentwurfs während des SUP Verfahrens und die endgültige Entscheidungsfindung erfordern eine verbesserte Transparenz der zu integrierenden Auswirkungen des Klimawandels.

Empfehlungen für entscheidende und kritische Handlungen werden an zuständige nationale und regionale Behörden der Raum- und Fachplanungen adressiert. Diese umfassen eine direkte Integration des Klimawandels in die SEA-REP, die regionale Operationalisierung von Umweltzielen für die Anpassung an den Klimawandel, eine verbesserte Kooperation zwischen Raum- und Fachplanern, die zuständig sind für die Planung der zukünftigen Nutzung von Fläche und Ressourcen, und nicht zuletzt eine Beteiligung der Öffentlichkeit bei der Festsetzung regionaler Ziele für den zukünftigen Umweltzustand in einer Region.

Nationalen und föderalen zuständigen Ministerien wird die Integration von materiellen Standards in bestehende Gesetze empfohlen. Verbindliche Standards für eine strengere Reduzierung des Flächenverbrauchs sollen festgesetzt werden. Klare Verantwortlichkeiten und Aktivitäten auf allen Planungsebenen sind zu bestimmen, sowie Richtlinien zu einer guten regionalplanerischen Praxis zu veröffentlichen.

Wesentliche Empfehlungen für europäische Regionalplanungsbehörden sind die Erstellung eines Konzepts für regionale Umweltziele für die SUP in der Regionalplanung, die Aktualisierung regionaler Umweltdatenprofile, die Anwendung der SUP in der Regionalplanung mit den LUCCA Indikatoren, die Entwicklung eines abschichtenden Entscheidungsfindungssystems, die Herausforderung der konventionellen Regionalplanung, die Verbesserung der Kooperation mit Fachplanungen und die Einbeziehung der Öffentlichkeit in die Aufstellung von Anpassungsstrategien.

Es sollen auf regionaler Planungsebene streng geschützte Vorranggebiete mit spezifischer Funktion der Flächennutzungen für die Verminderung der Erheblichkeit negativer Beeinträchtigungen des Klimawandels ausgewiesen werden. Solche Vorranggebiete sollen an die Umsetzung verbindlicher Anpassungsmaßnahmen in der Flächennutzungsplanung gebunden werden. Es ist erforderlich, dass die regionale Planungsbehörde die vorgeschlagenen Prüfschritte für die regionalspezifischen geographischen und bio-physikalischen Gegebenheiten operationalisiert.

Abschließend werden Vorschläge zum zukünftigen Forschungsbedarf und ein Ausblick auf das zukünftige Potenzial der SUP in der Regionalplanung gemacht. Verbesserte Umweltdaten über raumbedeutsame Auswirkungen des Klimawandels und eine Bewertung der Empfindlichkeiten sind für die Anwendung und Weiterentwicklung der SEA-REP und LUCCA erforderlich. Zusätzlich muss die Beteiligung der Öffentlichkeit in der SUP mehr Bedeutung erlangen und die Beschlussfassung dadurch transparenter werden. In der regionalplanerischen Abwägung benötigen Umweltbelange und der Schutz von LUCCA mehr Gewicht, wenn durch Effekte des Klimawandels und durch anthropogene Flächendegradation entstehende Gefährdungen und Schäden jetzt und zukünftig vermieden werden sollen.

Contents

Acronyms and Abbreviations

Cw	change of water balance
EC	European Commission
ECCP	european climate change programme
EIA	Environmental Impact Assessment
EU	European Union
EQO	environmental quality objective
EQS	environmental quality standard
F/B	fragmentation and barrier effect
Fl	directed flooding
GHG	green house gas
Gw	groundwater
Lc	land consumption
LEP	state land use planning at federal level
LfUG	Saxon agency for environment
LP	landscape planning at communal level
LRP	landscape framework planning
Lu	land use change
LUCCA	land use with importance for adaptation to climate change
m	metre
OL-NS	Saxon most eastern region of Upper Lusatia-Lower Silesia (Germany)
Po	positive impacts
REP	regional land use development plan (German)
ROG	German spatial planning act
RPB	regional planning body
SAC	special area for conservation (under the EC Habitats Directive)
SEA	Strategic Environmental Assessment (under EC SEA Directive)
SEA-REP	SEA of regional land use planning in Germany
SPA	special protection area (under the EC Wild Birds Directive 79/409/EEC)

1. Introduction

What is Strategic Environmental Assessment in Regional Planning?

The Directive 2001/42/EC of the European Parliament and of the Council on the assessment of the effects of certain plans and programmes on the environment (SEA Directive) legally requires Strategic Environmental Assessment of land use plans (here: SEA-REP), which are prepared by competent regional[1] authorities in EU Member States. SEA of regional land use plans is obligatory, and must be carried out by the local or regional planning authorities in the course of the plan-making (Art. 3 SEA Directive). SEA is a decision-aiding tool to provide for a high level of protection of the environment (Art. 1 SEA Directive), and thus to optimise the contents of a regional plan from the perspective of the environment under the sustainability and precaution principle.

Today SEA is a widely applied process in Germany for the identification, description and assessment of anthropogenic impacts of regional land use plans on the environmental media[2] (Bunge 2005a; Schmidt M. et al. 2005; Hendler 2002, et al. 2004). Contents of spatial plans, which set a framework for EIA projects or assessments after EC Habitat Directive and which cause likely significant environmental impacts, have to be assessed concerning their impacts on the environment (EC 2003: 15f). SEA potentially improves the quality and transparency of the regional plan-making weighting process.

Due to its strategic nature, SEA-REP focuses on if, when and where activities will be situated in terms of location choices for housing settlements, industrial sites, tourism facilities or excavation sites. Dotinga (2004: 238), for example, emphasised that the right moment for interventions in the planning process is "*upstream of the river*", i.e. at the moment when locations can still be chosen. The change of use and function of a particular area often leads to irreversible significant environmental consequences, which have to be made transparent and ideally avoided as early as possible in the spatial planning hierarchy. Once the soil of an area is to be sealed for a housing site and a valuable habitat is lost, it is very difficult to change the implementation of these interventions at lower planning level. In Environmental Impact Assessment (EIA) 'only' mitigation and compensation are possible (Arts 1998: 173). In EIA technical mitigation measures for climate change[3] are implemented, such as the enhancement of existent ditches and flood gates, and therefore adaptation of flood risk to the forecasted sea water level rise.

Why is Adaptation to Climate Change Necessary in Regional Land Use Planning?

In the context of increasing importance in the status of sustainability and environmentally-sound

[1] A region is defined as any area comprising of states or provinces within a country or a group of countries in a particular territory or zone. Regional plans lay down spatial objectives for the area as a whole and its constituent parts (here in a scale of 1.100 000 m to 1. 200 000 m), as well as the steps necessary to attain these objectives (Naseer 2004: 660).

[2] Here used synonymiously with 'natural resources'. The term includes non-renewable resources such as lignite, sand or petroleum.

[3] "*Climate change means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods*" (Art. 1 para 2 UNFCCC).

land and resource use in the EU, the implementation of climate policy and strategies for the adaptation to climate change became important and urgent tasks for the European regions. The awareness of regional planners in the EU of the importance of the integration of climate change into policies, plans and programmes at all planning levels and sectors has continuously increased. Although this was demonstrated by the launch of the Stern review (Stern 2007) and other strategies and activities[4], further research and methods for the integration of mitigation and adaptation strategies into SEA-REP are still required. Predicted effects of climate change on land use demand stricter and wiser decisions on priorities of land use, with the aim of preventing and mitigating flooding of housing areas, shortage of drinking water and high quality food, heat stress, and to mitigate carbon release through remediation of degraded land at a regional scale.

Worldwide, scientific research and knowledge on pressures global warming causes on regional land uses and natural resources is continuously and rapidly evolving. It is evident that global climate change cannot be combated and its negative effects on the European landscapes can only be mitigated to a certain extent. For example, Germany's head of state Horst Köhler stated in 2005 that the true environmental challenges are still to come and that climate change was not a distant future, but a current reality. At the same time the present rapid rate of globalisation, driven by economic forces and materialistic aims, is creating many environmental problems at regional level. Economic growth and intensification of land use causes progressive soil degradation (EEA 2000: 7ff), which demands remedy by all actors involved in decisions on land use including the EU regional land use planning at a scale of 1.100 000 m to 1.200 000 m.

This research was based on the opinion that the earth's climate change is a reality and humankind will not be able to combat it (this term is still often used in literature and in the media), but will 'only' be able to mitigate its adverse effects and adapt to its induced changes of the natural conditions and land uses. Therefore an urgent and timely adaptation of all sectors and at all planning levels worldwide is necessary. SEA-REP is an integrated process, which addresses all environmental media and includes the entire comprehensive regional plan with its spatially-relevant objectives and designations, as well as integrations of land use zones from other sectors such as agriculture and forestry. At regional planning level important decisions on land uses and the type and location of developments are made. Early preventive land management is seen as the better choice than reaction on future environmental degradation and hazards. The earlier in the planning hierarchy environmental conflicts are avoided, mitigated or compensated, the better it is in the frame of sustainability, as environmental precaution saves later costs, effort and time and reduces the significance of hazards, natural catastrophes and technical failure. The scale and level of regional planning in the spatial planning system allows site-specific allocations of land use. It is thus the highest tier for a futuristic preventive and sustainable land management.

Some typical environmental problems, which hamper objectives for the adaptation of regional land use to climate change are i) ongoing soil sealing, fragmentation and depletion of water resources; ii) loss of high quality soils for agricultural food production, loss of biodiversity or iii) overflow of

[4] For instance projects of the 6th EU Framework Programme such as ESPACE, ALARM, ENSEMBLES, ADAM, SENSOR or KLARA and INTERREG projects (e.g. ASTRA) as well as projects of the 7th EU Framework Programme and INTERREG IV delivered and will deliver important research results on the efficiency of different mitigation and adaptation strategies to effects of climate change.

precipitation water and flood water. Adverse effects of climate change[5] will add up to impacts[6] caused by regional development, directly and indirectly affecting European land uses and contributing to the level of degradation of the natural resources. Site-specific physical impacts of regional development will accumulate with adverse effects of climate change such as droughts, floods, heat waves, soil erosion or water scarcity with significant consequences for the regional populations and the environment. Whilst the vegetation and many animal species will be able to adapt to climate change step-by-step, if adequate refugia exist (EA 2006a), humankind needs a comprehensive adaptation concept, in order to prevent its existence and keep a high level of living quality. Therefore adaptation measures must be implemented at all planning levels and in all sectors, including comprehensive regional land use planning processes (BMU 2005: 41).

The EU environmental policy requires in its European Climate Change Programme (ECCP I and II) the mitigation of green house gas emissions and energy use on the one hand, and on the other the adaptation of all sectors and planning levels to climate change. The EU policy calls for more resources to be allocated to adapt effectively to climate change (EC 2005a: 7). "*To prevent or limit severe damage to the environment, society and economics, adaptation strategies for affected systems are required at European, national, regional and local level*" (EEA 2004: 5). Also Naseer (2004: 658) argued that especially global environmental problems need to be considered at higher policy, planning and programme level: „*during 1980s it was increasingly felt that large-scale issues that are causing deterioration of the environment (like ozone depletion or climatic change) need a broader scope of understanding beyond the project level.*"

Adaptation involves an early and proactive prevention of effort and costs of damage caused by global climate change. Cairncross (2006: 31) underlined: „*adaptation policies have had far less attention than mitigation, and that is a mistake.*" Humankind cannot rely on unlimited technical mitigation measures at lower project level, but it must overcome its hubris of trying to keep land uses of the past alive, e. g. urban areas in floodplains or artificial beaches on areas below sea level. Instead, higher land use planning will have the task to manage newly the future use of the area, which might involve abandonment of areas on the one hand, and stricter preventive regulations and criteria for designations of priority areas for future land use on the other. This requires a reformation of traditional German regional planning, to more strongly integrate climate change concerns and all stakeholders involved in adaptation and mitigation strategies.

How can SEA-REP Promote Adaptation to Climate Change?

SEA is deemed to be an adequate instrument to particularly assess the compliance of significant impacts of regional plan contents with EU and national objectives for the adaptation of land and resource use to climate change. With adaptation, intensification of land use, land consumption, fragmentation and physical degradation of essential natural resources that form a basis for life need attention in decision-making and require global, national and regional cooperation and management

[5] "*Adverse effects of climate change means changes in the physical environment or biota resulting from climate change which have significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare*" (Art. 1 para 1 UNFCCC).

[6] Impacts are quantitative or qualitative changes of natural resources, which exacerbate or make impossible with their type and scope the satisfaction of the need for natural resources caused by anthropogenic activities (Scholles 1997). In this thesis the term impact is used synonymously with the term effect.

(e.g. Dahl 2002; EEA 2004).

Efficient and high quality SEA is seen among environmental planners as having a great potential to contribute towards sustainable development and the precautionary principle through its early impact prediction, assessment, comparison of alternatives and proposal of mitigation measures at the higher plan and programme levels (Hartlik 2008). SEA-REP is a legally obligatory decision-making support process in the EU, which aims at an integration of relevant environmental objectives (Jacoby 2000). These include objectives for the adaptation of land use to climate change and the mitigation of adverse effects of climate change on EU regions' land and resources.

SEA-REP was considered as a suitable instrument to promote an improved implementation of EU and national environmental policy at regional scale. EIA alone could not prevent progressive degradation of European land and natural resources, as it came too late in the planning hierarchy (Elling 1997: 162). Regional land use planning combines the most important land uses and spatially-relevant developments in the EU regions for the next decade.

1.1 Background

The basis of this study are two years of research and experience in SEA assessment methods, gained by the doctoral candidate in the EU funded Interreg project 'transSEA'. The project involved a collaboration between the Department of Environmental Planning of the Brandenburg University of Technology Cottbus, landscape and regional planners from the Leibniz Institute of Ecological and Regional Development in Dresden and the Regional Planning Authority of Upper Lusatia-Lower Silesia (OL-NS) in Bautzen in Saxony (Reinke et al. 2005a, b; Stratmann et al. 2007a). Figure 1 presents the study region of Oberlausitz-Niederschlesien (Upper Lusatia-Lower Silesia). With the incorporation of objectives of the EC SEA Directive into the German national EIA Act (UVPG), federal EIA acts and Federal Spatial Planning Act[7] (ROG), methods were needed to evaluate, if the process and contents of regional land use plans comply with the SEA related legislation.

Figure 1: Study Area Upper Lusatia-Lower Silesia

(Source: Helbron & Schmidt M. 2008, changed from RPV OL-NS 2007)

[7] also called 'Regional Policy Act' (SMI 1997)

One such method for a site-specific assessment in SEA-REP is the development of an indicator system including the determination of assessment thresholds.

Critiquing available SEA-REP processes and methods from German case studies was ongoing throughout the lifecycle of the project and the resulting research, with the aim of developing a set of SEA-REP best practice standards for future German SEA-REP processes. The German spatial planning system was considered as adequate basis for this critique, due to its characteristics, which demonstrate a high level of integration of environmental concerns into spatial planning. It may therefore serve as a model for other EU regions.

The analysis of conventional German regional planning and SEA-REP case studies showed that adverse effects of climate change so far have not been sufficiently integrated into regional plan-making processes and decisions. Climate is considered as an environmental media as defined in legislation. Two primary shortcomings of the implementation status of environmental policy for the adaptation of land uses and natural resources to climate change in SEA-REP were identified:

- insufficient implementation of environmental objectives for the protection of land uses and natural resources against physical degradation at regional level;
- insufficient integration of spatially-relevant effects of climate change into SEA-REP and a lack of a systematic decision-support framework for lower land use planning tiers.

1.2 Objectives

The two primary aims of this research were to implement environmental objectives for adaptation of land use to global climate change, and to integrate the assessment of effects of global climate change into SEA-REP and its tiered system (figure 2).

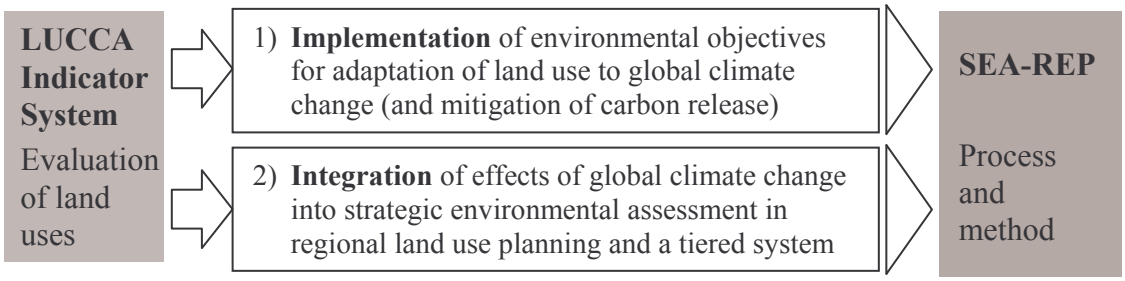

Figure 2: Primary objectives of the thesis

There is a tendency at EU and national level to orient environmental policy stronger at objectives, which ideally achieve rational and environmentally balanced decisions, which are made transparent for the public. SEA-REP is a tool to make the availability and level of obligation of environmental policy transparent. Where environmental objectives and standards exist, the regional planning body (RPB), which is the competent authority for SEA-REP, is required to state how they intend to comply with environmental objectives and standards in SEA (Annex I lit. e SEA Directive). A recognised insufficient operationalisation of environmental quality objectives and environmental quality standards at regional planning level was the incentive for the derivation of scientific recommendations of 'regional environmental orientation objectives'. These were determined and standardised by the author.

A primary objective of this thesis was to implement international and EU Climate Policy into the core assessment step of SEA-REP. "*Climate-proofing must be integrated into the Strategic Environmental Assessment (SEA) Directive*" (EC 2007a: 18). Beside objectives for adaptation to climate change, the national environmental target[8] of the German Government for the reduction of land consumption (GFG 2002) should be operationalised for the regional planning level. The reason was ongoing land consumption, which requires increasing awareness rising among regional and sector planners and a determination of stricter regional targets or threshold values for a consequent reduction of the soil sealing rate.

The opportunity of a vital reduction of land degradation and adaptation of regional land use to climate change with the help of SEA-REP is not to be missed, if a significant deterioration of the living quality in parts of Europe shall be mitigated or at least postponed. The integrating of land uses of importance for the adaptation to climate change (LUCCA) into SEA-REP, transparent environmental conflicts with regional plan designations, and corresponding decision-making should prevent from progressive physical degradation of the regional natural resources. SEA-REP cannot guarantee an 'environmentally friendly planning' and 'appropriate decisions', but it makes environmental consequences of the regional plan and the distance to climate policy targets transparent. It thus creates space for disapproval or acceptance by all stakeholders and the public. For this purpose an SEA indicator system should be developed, which could function as a standardised guidance for RPB. The aim was to contribute to best practice solutions and standard guidelines for an assessment process, which fulfills the target of an optimisation of the regional plan from the perspective of environmental objectives. A transferability of the guidelines from the German approach to other EU regions was deemed to be possible, due to common regional planning objectives and scale.

Secondary objectives of this research were to enhance the potential of SEA-REP to involve regional societies into decision-making. Site-specific regional plan designations and their alternatives should be characterised by type and dimension of their predicted impacts, which likely accumulate and intensify in their significance in combination with negative effects of climate change.

With this research also an approach should be made to pass on knowledge and experience from German current practice of the environmental assessment of impacts of regional plans to other EU Member States, and to support scientists and practitioners in the development process of adaptation strategies for the regional planning tier. A first result of a comprehensive literature research was: still only a few documentations of German SEA-REP case studies exist in the English language in literature. Fischer and Gazzola (2006: 399) calculated that less than 15 % of available international literature on SEA stems from Germany, in contrast to 47 % from The Netherlands and the United Kingdom combined.

Central Research Questions

- Which indicators and thresholds can be applied as methods for the identification, description

[8] Target = a quantitative level that is expected to be achieved by a given date. Its achievement can be monitored with indicators.

and assessment of environmental impacts of regional land use planning designations combined with effects of climate change?

- How can environmental quality objectives and environmental quality standards for the adaptation of land use and resources to climate change be operationalised at the regional planning level?
- What are benefits of the SEA-REP process as an instrument for improved protection of land and resources against degradation, adaptation of regional land use to climate change, and the mitigation of adverse effects on the environment?

1.3 Hypotheses

An indicator system with indicators and assessment thresholds can be developed, which operationalises climate change mitigation and adaptation policy and integrates adverse effects of climate change into SEA-REP. A systematic assessment process and an indicator system make environmental conflicts of site-specific regional plan designations with land uses with importance for the adaptation to climate change transparent. The environmental potential of regional designations for mitigation of carbon release can be ranked and accordingly considered with priority in SEA-REP. At the same time SEA-REP guidance for the setting of regional orientation objectives can be provided, which contributes to the raising of public awareness at regional planning level in the EU regions.

1.4 Methodology

An intensive and comprehensive research included different sources such as scientific books and journal articles, the internet, information and material from authorities, knowledge gained at transSEA scoping meetings, SEA conferences, international workshops, and through interviews with EIA experts. The analysis in the course of this thesis covered:

- experiences from ‘transSEA’ and other German SEA-REP case studies with emphasis on the assessment method;
- selective analysis of assessment methods applied in SEA case studies in spatial planning at regional level;
- internationally approved environmental and sustainability indicator systems;
- environmental policy with focus on climate change;
- approved assessment methods for SEA, EIA and planning.

Selective Analysis of Assessment Methods Applied in SEA Case Studies in Spatial Planning at Regional Level

Literature analysis was carried out for regional planning in EU Member States, which are characterised by the common framework of the EU environmental policy and procedural requirements of the SEA Directive. The method choice in the case studies was determined by the national legislative and planning system, objective and scope of the regional plan objectives, time, effort and costs invested by the RPB, availability of environmental objectives and data, as well as the demand for transparency. These factors could not be investigated in detail in the scope of this thesis. Criteria for the selection of analysed case studies were:

- their relevance for comprehensive spatial planning;
- quantitative assessment methods applied;
- site-specific consideration of significant impacts of REP contents;
- the assessment method was made transparent and was well documented;
- sufficient documentation was accessible in literature, SEA reports or the internet in German or English.

Internationally Approved Environmental and Sustainability Indicator Systems

In order to define minimum requirements and selection criteria for the LUCCA indicator system, internationally approved environmental and sustainability indicator catalogues and systems were investigated on the applicability of indicators for assessments within the scope and scale of regional planning.

Indicators were selected in direct connection to environmental targets. The operationalisation of environmental objectives through a derivation of adequate indicators and reference values is helpful for the determination of thresholds in absolute values. However, due to a lack of specific targets a certain part of the environmental objectives could only be described qualitatively in SEA-REP. The selection of 'environmental state indicators' was based on existent EU and national environmental quality objectives and environmental quality standards. Additional effort was made to define standardised regional environmental orientation values.

Environmental Policy with Focus on Climate Change and the Protection of Land against Land Consumption and Physical Degradation

The level of relevance of environmental objectives for the regional scale influences the implementation of regional targets for the protection of environmental potentials of land uses for adaptation and mitigation of carbon release. The significance of land use change and conventional REP designations for the implementation of these targets was analysed. Results aimed at were potentials and importance of designations of regional planning as contribution to climate change: how can regional land use planning contribute o the implementation of Kyoto Protocol targets? Which regional plan designations (integrated from which sectors) are the most important ones for adaptation to climate change?

Approved Assessment Methods for SEA, EIA and Planning

However, the SEA Directive leaves a high flexibility for interpretations and choice of methods including methods for prediction and assessment. Therefore the feasibility of different assessment methods, including quantitative indicator systems, requires specific attention and research. According to Thérivel (2004) and Hartlik (2008) important objectives of the implementation of SEA in the EU are practical applications, the development of guidance, as well as quality checks and training, which in the best case should be based on pilot projects. Several guidance documents for the national legal interpretation and implementation of the SEA Directive were analysed [e.g. EC 2003; ARL Ad-hoc Arbeitskreis Plan-UVP 2001, 2002; MKRO 2004; Eberle & Jacoby 2003 (Germany); ODPM 2005a, 2005b (England); ÖROK 2004 (Austria); Commission for EIA of The Netherlands 2001 (for the Netherlands)]. These represent a valuable basis for the practical application of SEA in the legal and planning context of the individual EU countries.

The selected methodological approach for SEA-REP and LUCCA not only had to complement the environmental assessment, but will have to satisfy its procedural attribute beside the environmental assessment itself. It was therefore a precondition that the SEA-REP assessment concept is REP objective-led and practice-oriented (Jessel 2005). The RPB will have to be able to handle the indicator system in practice without inquiring additional explanations, environmental data or further evaluations of the state of the environment. The following minimum quality requirements of the German SEA-REP impact assessment methodology were determined (Schmidt C. et al. 2004; Thérivel 2004; Albert et al. 1998; Wüst et al. 1991):

1. compliance with the requirements of the EC SEA Directive;
2. following objectives of the precautionary principle and sustainable development, as well as objectives for adaptation to climate change and mitigation of adverse effects;
3. adequacy of significant environmental impacts for the status of the regional plan;
4. transferability of the assessment method to other REP plan makers in Germany or other EU Member States;
5. practicability of a systematic, understandable process for the competent regional planning body, which does not need specific additional explanations to understand the indicator system and assessment method;
6. understandable, well documented assessment criteria and thresholds, quantifications and aggregations;
7. definition of a comprehensive, but flexible scope;
8. allowance of valid results, which can be linked to economic and social subsystems;
9. support of improvement rather than just an analysis of the strategic action;
10. consideration and documentation of proposed different alternatives and comparison in a specific assessment context;
11. clear link to landscape framework and other sector planning.

1.5 Structure

The thesis is structured into six main chapters (chapter 1-6), which address the above mentioned objectives of the research (see figure 3). It begins with chapter 1 introducing into the research. Chapter 2 deals with the relevance of international, EU and national environmental policy for SEA-REP. These legal and planning requirements are operationalised in form of regional environmental orientation objectives, which are linked to the selection of LUCCA indicators.

In chapter 3 the process, methods and indicators for the assessment of environmental impacts of regional planning were analysed and described in detail on the basis of German SEA-REP current practice. An emphasis was put on physical degradation of land use and natural resources, and land uses with relevance for the mitigation of effects of climate change and/or spatial adaptation to global climate change. Therefore predictions of spatial effects of climate change were summarised as a basis for a changing state of environment in Europe. Regional plan contents subject to the two tiers of a site-specific assessment and overall assessment of the regional plan were identified.

Chapter 4 takes a look at the method for the classification of environmental conflicts as a result of regional plan impacts affecting the evaluated importance of environmental components and LUCCA. The definition of ranges of precaution, concern and harmful effects, and derivation of assessment thresholds is explained. The conflict intensities can be used to compare alternatives and

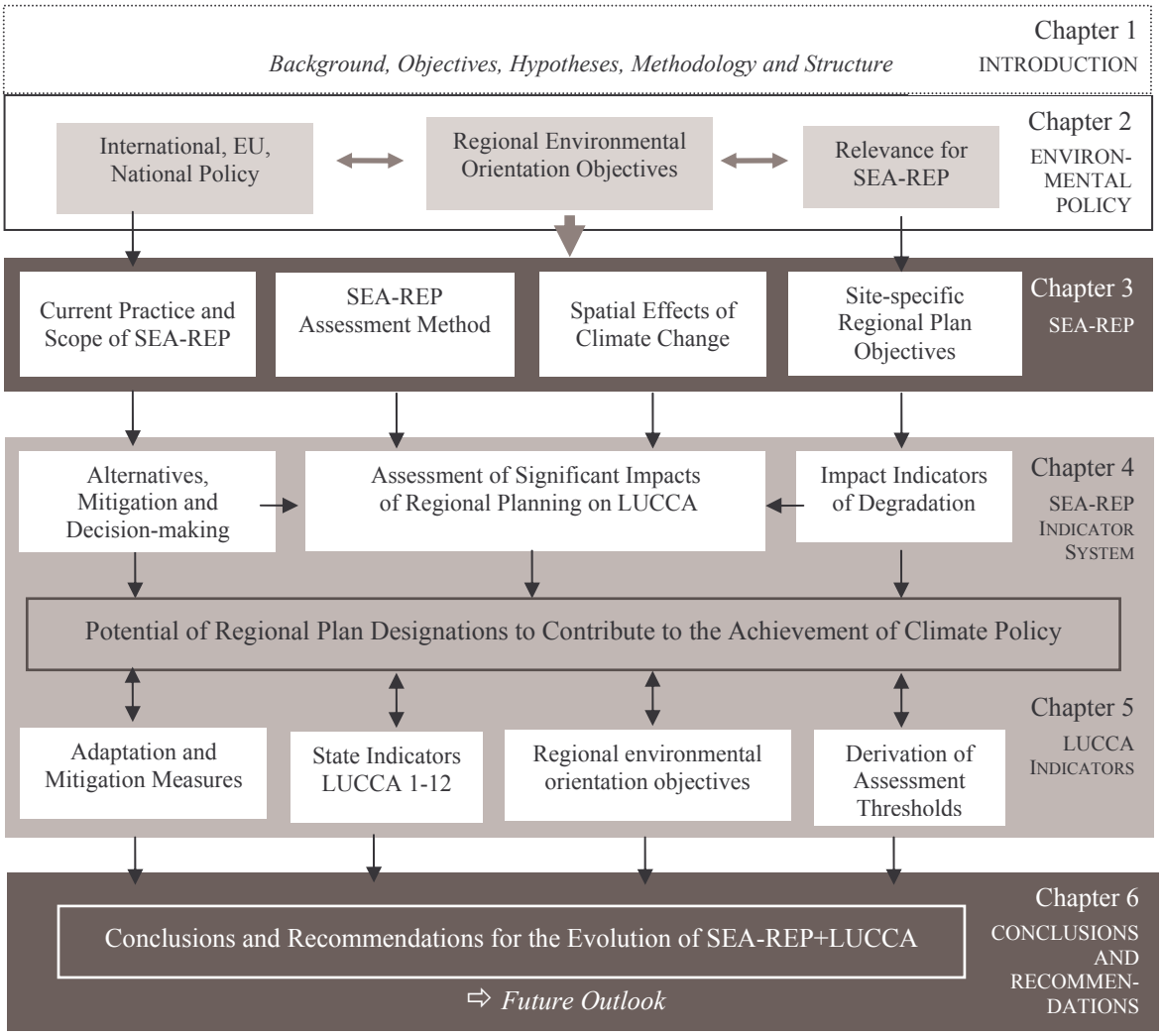

Figure 3: Structure of the thesis

to set priorities for the implementation of conflict mitigation measures. The chapter ends with recommendations for final decision-making and follow-up.

Chapter 5 presents and discusses the proposed 12 LUCCA state and impact indicators and their assessment thresholds. It is closely linked to the assessment method described in the previous chapter. Conflict intensities of regional plan impacts affecting an evaluated importance of these land uses on the affected area and impact zone are proposed. For each LUCCA indicator relevant regional environmental orientation objectives, indicators and derivation of assessment thresholds are listed.

Chapter 6 finally delivers guidelines and recommendations for the future evolution of a site-specific assessment in SEA-REP. Moreover different spatial planning tiers and sector planning are addressed. The thesis finishes with an outlook, which includes reflections on the future potential of SEA as an instrument to improve a regional plan and initiate changes in traditional regional planning.

2. Analysis of Environmental and Spatial Policy

Available environmental objectives from EU, German and Saxon spatial and environmental policy are identified and categorised in the course of SEA-REP (Annex I, fig. e SEA Directive). Many environmental quality standards implemented in German national and federal legislation are based on EC Directives. Environmental targets for each environmental media can be derived from the general environmental policy guidelines and environmental quality objectives, which are essentially formulated in the national sector and comprehensive laws such as the German Federal Nature Conservation Act (BNatSchG), Spatial Land Use Planning Act (ROG), Water Resources Act (WHG) and the Federal Soil Protection Act (BBodSchG). The national spatially-relevant objectives are operationalised with the Federal State Land Use plans. Special focus during the analysis and compilation was put on environmental-political objectives of the German Government, which are specified quantitatively and/or in time. These are laid down for instance in international conventions, in EU legislations or decisions of the European Commission, in national legal provisions or in publications of the respective federal government (UBA 2001, 2005).

Definitions

The German Federal Agency for Environment (UBA 1995: 29) defined environmental quality (ecological status quo) in the stricter sense as the entirety of the structures and functions of an ecosystem considering both 'natural' biological and non-biological conditions and anthropogenic effects (e.g. uses). In the general use of the term it additionally presents a connection of scientific information with social objectives and value systems. Environmental quality objectives and environmental quality standards specify or refer to certain qualities of resources, potentials or functions defined in material, spatial or temporal terms, which are to be preserved or attained in specific situations. They may be scientifically, legally or politically defined, and expand on general environmental policy and environmental planning objectives. Derived from these objectives, environmental quality standards give specific values for day-to-day environment policy and address certain parameters and indicators, measuring methods and conditions. In environmental assessment environmental quality standards function as specific assessment criteria, which operationalise environmental targets by defining the target specification, the measuring method and basic conditions of a specific parameter or indicator (Scholles 2001).

Importance of Environmental Objectives, Standards and Thresholds in SEA-REP

Environmental objectives and standards are needed in SEA-REP in order to derive regional environmental orientation objectives and environmental state indicators with defined assessment thresholds (see figure 4). Existent international, national and regional environmental objectives are compiled in SEA-REP with the aim to select state indicators and determine assessment thresholds to classify environmental conflict intensities (Scholles 1997: 160ff).

Indicators can make transparent, which regional self-defined targets were achieved, or reveal whether adequate environmental data was compiled and applied. An evaluation of global climatic effects on all natural resources should be striven for. Walz (1997: 237) saw in the adequate consideration of ecological interrelations an essential quality requirement of indicator systems.

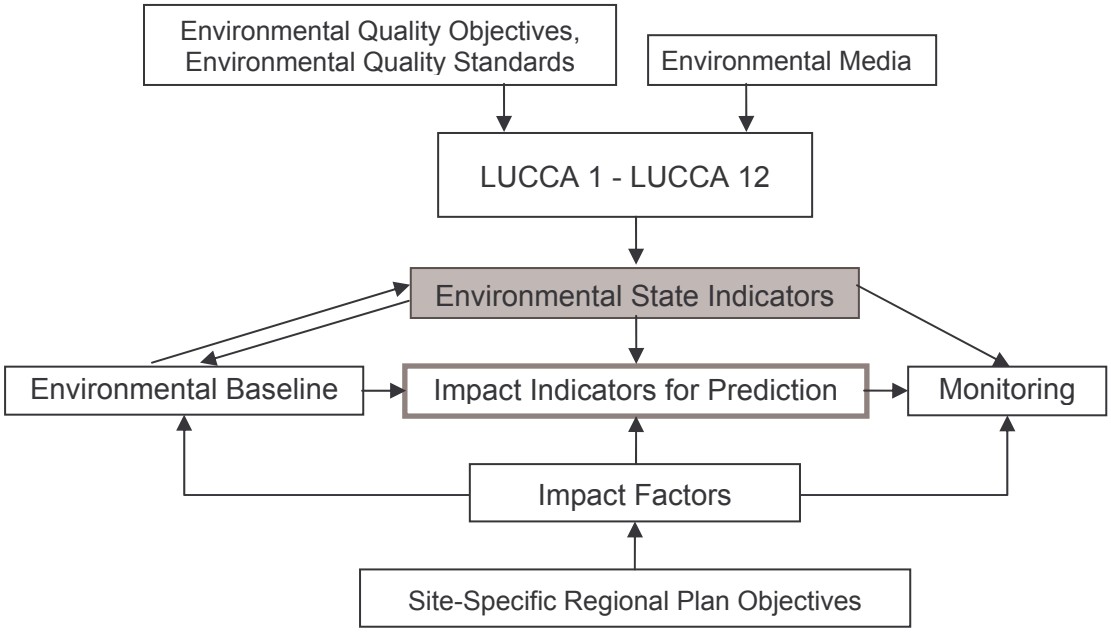

Figure 4: Link between environmental objectives, indicators and regional planning objectives

(Source: changed from CCW et al. 2004a).

In SEA-REP the environmental significance of predicted impacts and alternatives and practical consequences for avoidance and mitigation of these impacts are assessed (Bechmann & Hartlik 1996). In order to get a result of an evaluation, it is necessary to analyse how far the current situation of the environment is from any established threshold or environmental objective. Environmental quality objectives and environmental quality standards set targets, which must or shall be achieved in a specific region in a certain time frame. They can be divided into groups on the basis of the source of the impacts or their receptors (environmental media and their ecological carrying capacity) (UBA 2001):

- area-related: designated areas for the protection of open space and landscape or a general protection of site functions and potentials;
- media-related: protection of the environmental media soil, water, air and climate etc. against e.g. land consumption, pollution, noise, temperature increase;
- substance-related: prohibition or avoidance of production, utilisation and consumption, emission and deposition of environmentally harmful substances.

This research focused on area- and media-related objectives.

2.1 Operationalisation of Environmental Objectives

Relevant international, EU and national environmental quality objectives and environmental quality standards for all environmental media, including targets for the mitigation of carbon release and adaptation to effects of climate change, can be operationalised for each specific SEA-REP and for a specific region with state indicators and assessment thresholds (Sommer et al. 2002b; Helbron & Schmidt M. 2008). Operationality is defined as the condition, that all targets are determined in

time, can be achieved biologically, technically, economically and politically and can be quantified (Schreiner 2004: 182). The national and regional operationalisation of environmental policy is directly interrelated with the effectiveness of SEA-REP. The availability and quality of environmental objectives, standards and data in a region will influence the success of SEA-REP, as environmental state indicators are derived from environmental targets. An analysis of international, EU, national and regional environmental quality objectives and environmental quality standards is undertaken based on their:

1. relevance for the area and land use in a region;
2. relevance for the regional land use planning level (and link to other spatial planning tiers);
3. level of obligation; and
4. significance for mitigation and adaptation.

The identification of environmental targets on the basis of their level of their legal obligation and importance for the achievement of climate protection and land consumption policy creates a framework for priorities in the protection of land uses and the mitigation of negative impacts of regional plan objectives with the help of SEA-REP.

Currently at German regional planning level, there exists a general lack of area-specific environmental objectives for the protection of the land, natural resources and their carrying capacity against land consumption and land use change (Hülsmann 2001; Stock 2005; Storch & Schmidt 2008). This is one reason why the current tendency of soil sealing in Europe does not conform to sustainable development (EEA 2006). Figure 5 visualises the current implementation deficiency of environmental quality objectives and environmental quality standards in the EU for the strictly binding protection of land and natural resources against land consumption.

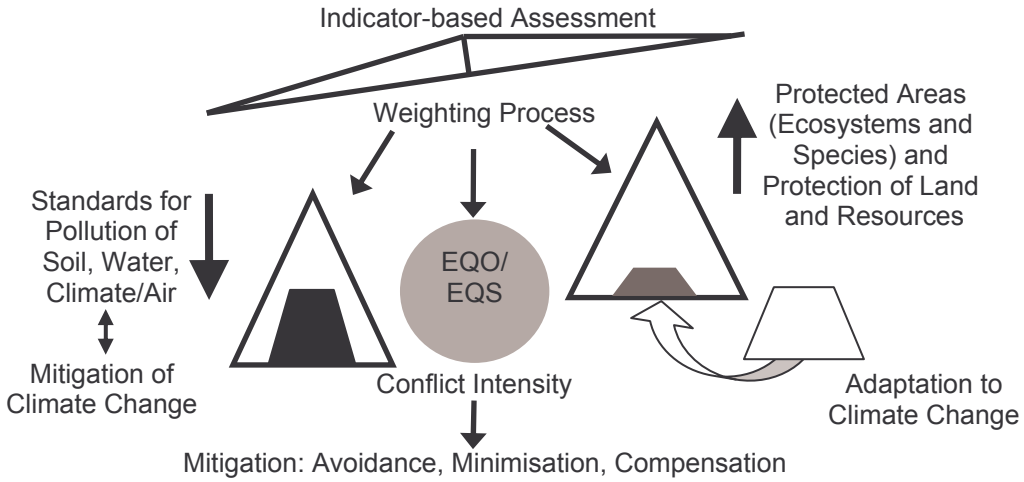

Figure 5: Under-represented area-specific binding environmental quality objectives (EQO) and environmental quality standards (EQS) for the protection of land and resources in the EU

(Source: modified from Helbron & Schmidt M. 2008)

German regional planning traditionally integrates strict legally binding protected areas from nature conservation, minimum distances and buffers of designated zones. These planning instruments are widely approved and implemented in practice. Also the concept for open spaces is well developed

in regional planning. But, existing objectives to reduce land consumption are not in an adequate way spatially or functionally differentiated, and are not specified spatially and in contents in the hierarchical planning concept on all levels.

At the same time the EU target of a reduction of the average air temperature increase by global warming to 2°C (EC 2005a: 7; BMU 2007b) and adverse impacts of climate change, which are predicted in science, are currently not sufficiently addressed. A main focus of EU policy lies on mitigation measures through prevention and reduction of pollution of soil, water and climate/air (see left 'heavier' scale pan of figure 5). Mitigation is particularly aimed at carbon dioxide (CO_2) and other greenhouse gas (GHG)[9] emissions into the air, which mainly originate from traffic, energy and industrial production.

Area-related adaptation measures are not yet implemented with the same weight at national and regional spatial and sector planning levels in the EU (see right 'lighter' scale pan of figure 5). Regional plan objectives particularly influence the pressure on the land by decisions on the spatial distribution and location of plan designations. The lack of strict legally binding environmental quality standards to regulate land degradation faces an 'overweight' of binding environmental standards for the protection of the environmental media water, soil and air against pollution with noxious substances. Another current problem is the implementation deficiency at regional planning regarding the mitigation of cumulative conflicts of land use planning with adverse effects of climate change through adaptation of planning systems.

Schmalholz (2004: 74) saw an advantage in a further legalisation by environmental objectives, as a voluntary implementation is hardly achieved. A higher level of obligation would lead to a better consideration of environmental concerns in political and administrative decision-making processes, higher legal security and better possibility for control. A disadvantage of a further legalisation would be a loss of flexibility and regional specifications, which are of special importance under the precaution principle. Also various concerns influence the setting of strict legally-binding objectives and standards, which cannot always favour each sector or media affected.

In summary, the essential problem in German environmental policy is not a lack of binding objectives or standards, but a specification in terms of operationalisation and regionalisation, and the consequent implementation of environmental and sustainability objectives. It is necessary to more precisely determine addressees and activities as well as adequate levels of detail at different planning levels (Schmalholz 2004: 77).

2.2 Objectives for the Protection of the Land and Adaptation to Global Climate Change

In the context of global climate change the implementation of EU climate policy and strategies for the adaptation of land use and the mitigation of likely future adverse effects on human health and the environment become an urgent task for all European regions. The operationalisation of national

[9] "*Greenhouse gases means those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation*" (Art 1 para 5 UNFCCC).

environmental policies at regional planning level must be promoted, if an early response on changed conditions of all environmental media and the land shall be achieved. A proactive and objective-led approach of SEA considers potentials, sensitivities and the carrying capacity of the region's state of environment and future development of their land use (e.g. Succow 2006, 2008a).

The 'growing together' of the EU Member States requires a higher activity of sustainable land use planning. The increasing permeability of the borders within the EU also needs transborder strategies for adaptation of objectives of spatial and sector planning systems to climate change. With the UN Espoo and Aarhus Convention the transboundary EU planning systems and decisions shall increasingly be made transparent for the people living in the EU. Not only transborder impacts and land uses require a transparent cooperation and common management, but also investors have an interest in understandable information on future regional environmental conditions in the EU. Europe-wide consistent standards for the process and contents of environmental assessment shall be achieved (Spannowsky & Krämer 2004). The EU is increasingly influencing national legislations by creating the policy framework for environmental protection (Möckel & Köck 2007). Such an increasing need for precautionary measures and sustainable development across the EU includes environmentally sound land use at regional planning level.

2.2.1 Protection of Land and Resources against Physical Degradation

The European policy sector of soil protection implements climate policy with the proposal of the Soil Protection Framework Directive (Scheil 2007). In Germany, the Soil Protection Act (BBodSchG), Spatial Planning Act (ROG) and Building Code (BauG) demand a sparse and sustainable use of soil. The German national sustainability target of the Government is set for a reduction of new sealed soil down to 30 hectares per day by the year 2020 (GFG 2002). Regional responsibility and spatial planning measures are explicitly mentioned in connection to this target. The Enquête Commission of the German Parliament proposed in 1998 the action objective, to achieve by 2010 a reduction of the conversion rate of undeveloped areas into settlement and transport areas by 10 % of the rate of the years 1993 to 1995, which makes up 12 hectares per day by the year 2010 (German Parliament 1998). The friends of the earth of Germany (BUND and Misereor 1996) even recommended a zero growth by 2010.

However, in view of the current intensive land use for urban settlement and transport infrastructure there is no guaranteed trend reversal of land consumption in Germany as yet. If the status quo of the land consumption rate is kept, the German territory will be completely built-up within the next 80 years (BMU 2007a). German urban regions are characterised by suburbanisation of the population, which results in more people living in the suburbs than in the city centres with high development pressure on the periphery (BMVBS/BBR 2007). Reasons of the increase in land take consumption were increased material prosperity and living standard with increased individual demands for the use of space[10] (BBR 2000; Hülsmann 2001). The increase of the urban area took place independently from the population development and minimum thresholds for urban densities.

[10] The population disperses on an increasing settlement area: in 1950 each inhabitant in former Federal Republic of Germany could use an average of 350 km² settlement area; in 1997 it was 500 km² ; within this period the individual consumption of housing area increased from 15 km² per inhabitant to 38 km² per inhabitant (see BBR 2000).

So far this ongoing process of land consumption was tackled mainly at lower communal level in binding land use planning (Sedlack 2004), but not sufficiently in a more precautious approach at higher planning level. The current lack of strict regional environmental objectives for the protection of the land and resources against soil sealing is not a new problem in Germany, but was already recognised before the early 1990s (UBA 1993). However, no efficient implementation of environmental objectives and activities for an improved area-wide protection of land and resources followed so far. The constant development shows that regional and urban planning assessment methods for a more efficient land-use management are highly ineffective in the final evaluation (Apel et al. 2000). Existing spatial and environmental planning instruments were not efficient to achieve the national sustainability target so far[11] (figure 6) (Dosch 2002; Runkel 2004; StBA 2005).

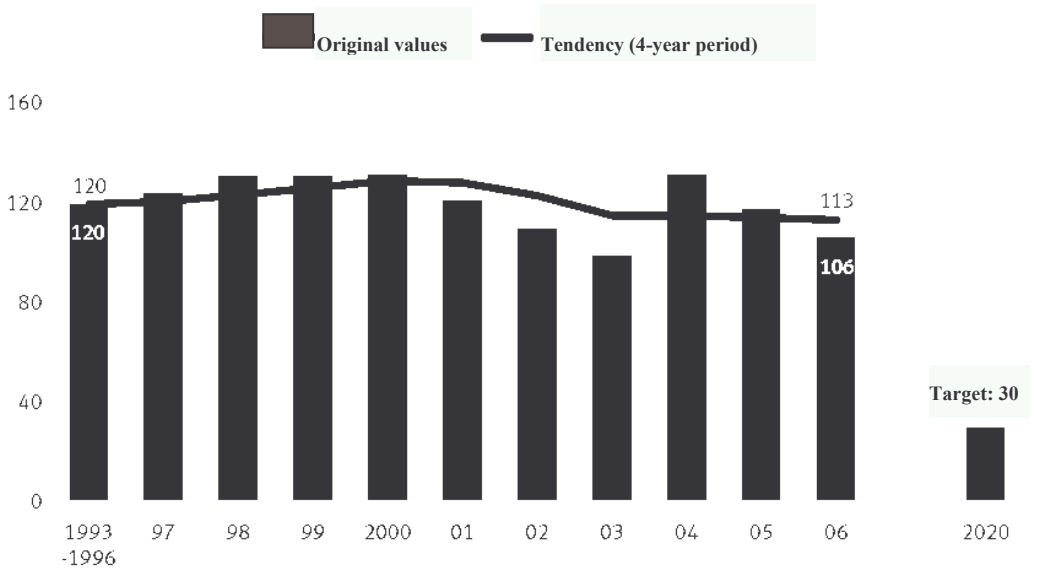

Figure 6: Increase of the urban and transport area in Germany in hectares per day (due to changes of data gathering the presentation is biased at the edge)

(Source: StBA 2008)

The German Federal Office for Building and Regional Planning (BBR 2005) predicted an average development trend of 104 hectares per day in the next 15 years from 2005 to 2020. Strict interim targets for these final targets are missing and respective thresholds of area shares operationalised for the German federal states are partly not mentioned in the state land use plans (e.g. in the LEP for Saxony (SMI 2003)). A main deficiency of the traditional hitherto process in regional development planning during the coordination of the commercial-industrial planning lacks a consideration of the factor 'area' in the course of the dedication of functions to individual municipalities (UBA 2003; Storch & Schmidt 2008).

Current German regional planning does not sufficiently promote the use of brownfields or the designation of compensation areas to be desealed, and lacks a consequent consideration of the type

[11] With 120 hectares from 1993 to 1996 per day in a 4-year period (Dosch 2002: 33); 129 hectares from 1997 to 2000 per day in a 4-year period; 115 hectares from 2001 to 2004 in a 4-year-period (StBA 2005: 6).

and value of soil that is being sealed. Relevant designations in REP for the protection of land are priority areas for nature conservation, recreation and remediation of natural resources. In Saxony a minimum area share for the operationalisation of the national environmental quality objective for the designation and protection of an area share of 10 % of the national territory as biotope connection areas, defined in Art. 3 para. 1 BNatSchG, was not yet fixed in the Federal State Land Use Plan (LEP) (SMI 2003). Regional adaptation objectives require more specific targets for urban development, agricultural land use (covering approximately 50 % of Germany's territory) and forestry (covering approximately 30 % of Germany's territory) (StBA 2004), in order to preserve a high living quality in a region under effects of climate change. Moreover the time span of the GFG objective for a reduction of land consumption is with over 18 years from 2002 until 2020 very long, so that the risk increases that the efforts made to achieve this aim are not strong enough. If the time span was shorter and included regional interim targets, the efforts to achieve the target would probably be stronger.

2.2.2 Objectives for Mitigation and Adaptation

The overall vision of an area and sector wide policy framework is the integration of environmental and social concerns into economic developments at all planning levels as defined in the Sustainability Strategy of the EU and pursued in the Sixth Environment Action Programme of the European Community. "*Action must be taken by all and at all levels*" (EC 2001: 5). This includes the implementation of objectives for climate change according to the United Nations Framework Convention on Climate Change and its Kyoto Protocol (Arts. 2 and 4 UNFCCC 1992; UN 1998). Potential SEA-REP "*measures to prevent, reduce and as fully as possible offset any significant adverse effects on [climate change] of implementing the plan or programme*" (SEA Directive, Annex I, lit. g) can be divided into mitigation and adaptation measures (figure 7; CCW et al. 2004b: 6).

2.2.2.1 Protection of the Global Climate by Mitigation

Mitigation measures, as defined in Annex I lit. g SEA Directive, aim to avoid, minimise or compensate negative effects caused by human developments, here decided as spatial REP contents and designations. In the context of global climate change mitigation measures bring about the reduction of GHG emissions as required in the Kyoto Protocol to the UNFCCC and implemented into Government strategies and targets of the EU Member States (UN 1998). The overall objective is to limit the global average temperature increase to a maximum of 2°C by 2020 and to mitigate forecasted accompanied effects on human health and the environment (EC 2000; BMU 2007b).

The EU strategy on 'winning the battle against climate change' (EC 2005a: 7) aims at a technical translation of the ultimate objective of a 2°C maximum temperature increase into policy terms, increased public awareness and better focused research to predict the impacts at regional level[12]. Global costs of mitigation can also be minimised under the full exploitation of synergies with other important spatially-relevant EU policy objectives such as the sustainable development strategy and

[12] Mitigation also includes economic instruments of the Emmission Trading Directive: Joint Implementation and Clean Development Mechanisms (CDM), which are well transposed into EU law and are linked to regional businesses.

the continuing reform of the Common Agricultural Policy (CAP) (EC 2005a: 16). The planned EC Soil strategy aims at a stricter protection of soil organic matter as it is the largest terrestrial pool of carbon (EC 2007a: 18). Land use change such as afforestation (Art. 3 para 3 Kyoto Protocol) can contribute to the reduction of carbon release.

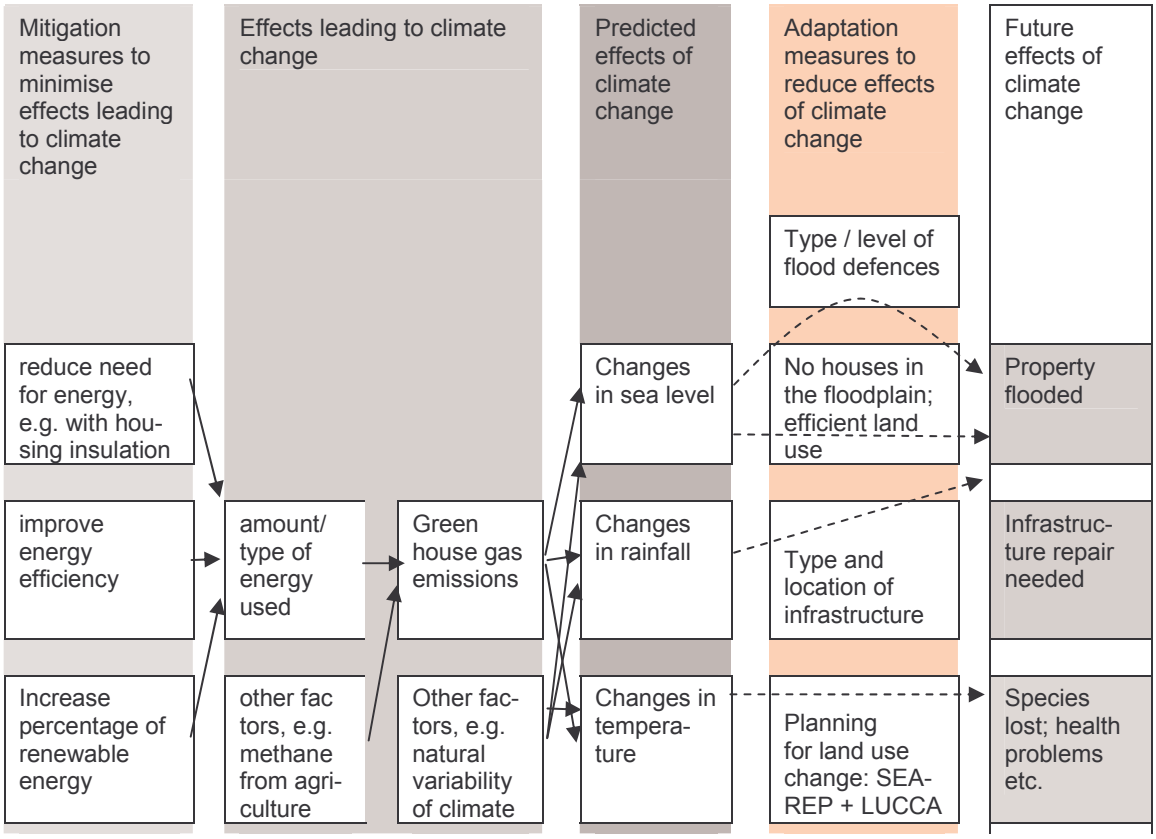

Figure 7: Effects of climate change and adaptation measures

(Source: modified from CCW et al. 2004b: 2)

2.2.2.2 Adaptation to Effects of Global Climate Change

Adaptation was defined by EEA (2004: 79) as early and preventive preparation of the society for consequences of inevitable climate change. The reduction of GHG emissions on its own, as a mitigation measure, will not stop the human induced climate change, which is expected to cause considerable impacts on the environment, human health and various sectors of society. An emphasis in this study is put on anticipatory adaptation measures of an early and preventive land use change (EC 2007a: 3).

Box 1 lists Kyoto Protocol targets with relevance for mitigation and adaptation of land use to climate change. Objectives for the adaptation of land use to climate change address all sectors, but particularly forestry management and agriculture. Explicitly mentioned as an adaptation measure in Art. 10 (b) is the improvement of spatial planning. The second European Climate Change Programme (ECCP II, 2005) and the EC Green Paper (2007a) emphasise area-specific impacts and adaptation to climate change. Adaptation involves a reduction of the vulnerability of land uses and an increase of their resilience to the effects of climate change (EC 2005a: 7). Thus adaptation of regional land use potentially contributes to the prevention or reduction of severe damage to the en-

Box 1: Kyoto Protocol targets with relevance for mitigation and adaptation of land use to climate change

Art 2. (ii) of the Kyoto Protocol requires a „protection and enhancement of sinks* and reservoirs of greenhouse gases“ and a „promotion of sustainable forest management practices, afforestation and reforestation“;

Art 2. (iii) determines a „promotion of sustainable forms of agriculture in light of climate change considerations“;

Art. 3 No. 4 proposes „additional human-induced activities related to changes in greenhouse gas emissions by sources+ and removals by sinks in the agricultural soils and the land-use change and forestry categories“

Art. 10 (b) demands to „formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures to (…) facilitate adequate adaptation to climate change (i) [concerning] (…) the energy, transport and industry sectors as well as agriculture, forestry and waste management. Furthermore, adaptation technologies and methods for improving spatial planning would improve adaptation to climate change.

*”Sink means any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere” (Art. 1 para 8 UNFCCC).

+“Source means any process or activity which releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere” (Art. 1 para 9 UNFCCC).

vironment, society and economies, and ensures sustainable regional development under changing climate conditions. A regional spatial plan should regulate and implement adaptation measures such as:

- flexible options, which can integrate further measures and strategies in the future; and
- ‘no-regret’ or ‘low-regret’ adaptation options, which deliver net benefits, “*whatever the extent of climate change*” (CCW et al.2004b: 6).

An optional adaptation measure is ‘planning for land use change’ (figure 7), which should be implemented in German regional land use planning. The implementation of international Kyoto Protocol and national climate protection targets for mitigation and adaptation to a changing global climate deserve more transparent attention in regional planning (EC 2005a: 7; BMU 2005: 41). For instance the Department for Communities and Local Government of the United Kingdom (DCLG 2006: 16, cit. in Glasson & Marshall 2007: 223) saw some main responsibilities for regional planning bodies in:

- helping securing carbon sinks through land use planning;
- avoiding new developments in areas with likely increased vulnerability to climate change; and
- bringing forward adaptation options for existing development in likely vulnerable areas.

2.3 Relevance of Objectives for Strategic Environmental Assessment in Regional Land Use Planning (SEA-REP)

2.3.1 Relevance of Objectives for the Area and Land Use

Climate change policy is a cross-cutting policy topic, which influences spatial and sector objectives on land use. Adaptation strategies to climate change are not yet implemented into the German national Spatial Planning Act, EIA Act or sector laws, but these provide spatially-relevant sustainability objectives. Regional land use planning as a comprehensive planning, integrating all

spatially-relevant land uses of a region, is an adequate planning level to influence sustainable development of a region, as contents are subject to a balancing process with compromises between land use conflicts. It therefore can potentially contribute to achieving the environmental target for reduction of land consumption and adaptation to effects of climate change by designation areas for a consequent protection of land uses of importance for climate change, e.g. with *high potential* for water and carbon storage, or the remediation of degraded land. It can also integrate objectives for the achievement of a determined future environmental state of existent land uses. A specific focus on the national and regional implementation of objectives for the adaptation to effects of global climate change was not legally fixed in the EC SEA Directive, nor integrated into the German EIA Act. Adaptation will be mainly necessary in urban areas affected by heat stress, in floodplains, or in coastal zones below future sea water level. The sector planning of transport, energy, urban planning, agriculture and forestry are essential spatially-relevant actors in the implementation of adaptation strategies. Regional planners integrate priority areas for agriculture and afforestation, but do not have direct influence on these land uses.

2.3.2 Relevance of Objectives for the Regional Scale

A German regional plan makes own regulations in form of designations, and integrates objectives and contents from sector planning as result of a weighting process, where all conflicting land interests are balanced according to national spatial planning principles regulated in legislation (Thérivel et al. 1992: 19f; Sadler & Verheem 1996; Partidário & Clark 2000: 4).

Land use plans at regional spatial level are defined with various terms in different EU countries under different legislations. According to definitions by Wood and Djeddour (1992, cit. in Wood 2002: 335), they are either plans as "*a set of coordinated and timed objectives for implementing the EU and national policy*" or programmes as "*a set of projects in a particular area which implement a plan.*" Naseer (2004: 660) defined a region environmentally and specifically in SEA, as any area comprising of states or provinces within a country or a group of countries in a particular territory or zone. Regional plans lay down spatial objectives for the area as a whole and its constituent parts, as well as the steps necessary to attain these objectives. Following this definition a German regional plan is a programme, which provides area-specific more or less binding regulations. An example for a higher spatial policy decision would be whether or not to promote the development of renewable energies in a country. A higher spatial state land use plan decision would be to achieve a share of 10 % of renewable power by 2020. A regional plan decision would be a specific number of designated sites for wind energy use with a specific potential capacity in specific areas to be implemented by 2020.

2.3.3 Tiered System in SEA of Spatial Planning

Tiering is required in SEA after Art. 5 No. 2 of the SEA Directive. It refers to the coverage of one level of environmental documentation in an SEA (top tier), followed by more detailed analyses of significant impacts and environmental documentation for a site-specific action at binding land use planning or project EIA level (bottom tier) (Jessel 2005). In this context tiering refers to the coverage of one level of environmental documentation in SEA-REP, followed by more detailed analyses and environmental documentation for a site-specific action at zoning planning, binding

land use planning or project EIA level (adapted from Jain et al. 2001: 115). The subsequent EIA need not repeat in full the issues treated in the SEA-REP, but may summarise the issues discussed in the broader statement and concentrate on issues specific to the subsequent action (Jain et al. 2001: 115; Thérivel 2004; Fischer 2002: 191). Integrated contents from sector plans do not have to be assessed in SEA-REP, if these were already subject to SEA. If REP contents have already been assessed at higher regional level, then, at binding land use planning, only the more specific objectives and designations have to be assessed in SEA (Grotefels 2006: 29). As Jessel (2005: 365) points out "*it has to be made sure that there is a working linkage providing that Project EIA can build up on the results of SEA.*" Impacts of REP contents on environmental components, which cannot be assessed at regional planning level, are tiered up or down. Reasons can be data and scale issues, a lack of information or details of information and responsibilities for plan contents lying with other (sectoral) plans and programmes or other assessment methods such as the EC habitat assessment. Recommendations of SEA-REP for adaptation measures to climate change at lower land use planning level can be documented in the environmental report.

In Germany the framework for spatial planning is created by the basic law and policy guidelines of the Government and Coordination of Ministers of State and Laender (MKRO 2004). With the German federalism reform from 2006, national framework legislation was abandoned in favour of a strengthening of the legislation of the federal states through a clearer determination of their legislative powers. Spatial planning now belongs to the concurrent legislation of the state and the federal states according to Arts. 74 para.1 No. 31 and 72 para. 3 No. 4 of the German constitution. The federal states can now release land use planning acts, which diverge from the national Spatial Planning Act (ROG). SEA in spatial planning is binding for the RPB with the ROG and Land use Planning Acts (LPlG) of the federal states, which specify requirements of the German EIA Act (UVPG) (Bunge 2005a: 103). Regional planning in this thesis represents the intermediate position between lower urban land use planning by local authorities and the higher state land use plans drawn up at state or federal level (figure 8; Art. 7 para. 5 subpara. 8 ROG; Art. 2 para. 4 No. 5 BauGB). It is defined as the overall spatial land use planning at regional scale or state land use planning for large partial areas of a federal state, which is directly binding for official bodies and indirectly for private persons (Spitzer 1995: 47ff; SMUL 1997). Regional planning objectives create a framework for the lower land use planning and project level (vertical tiers). It has the task to specify subordinated provisions in contents and space and steer a region into the direction of a long-lasting environmentally-sound use of land and resources and a regional sustainable development (ARL 1997; BUND & Misereor 1996). SEA at the lower planning level assesses additional impacts to those assessed in SEA-REP (Jacoby 2000; 2005: 26). SEA-REP therefore can function as a decision support system with regulative or even binding requirements for the implementation of adaptation strategies on lower tiers (box 2). This includes spatially-specific priority areas for adaptation of land use in the bio-geographic context of a region. Sectoral planning (horizontal tiers) must in the same way contribute to the adaptation of land use to climate change.

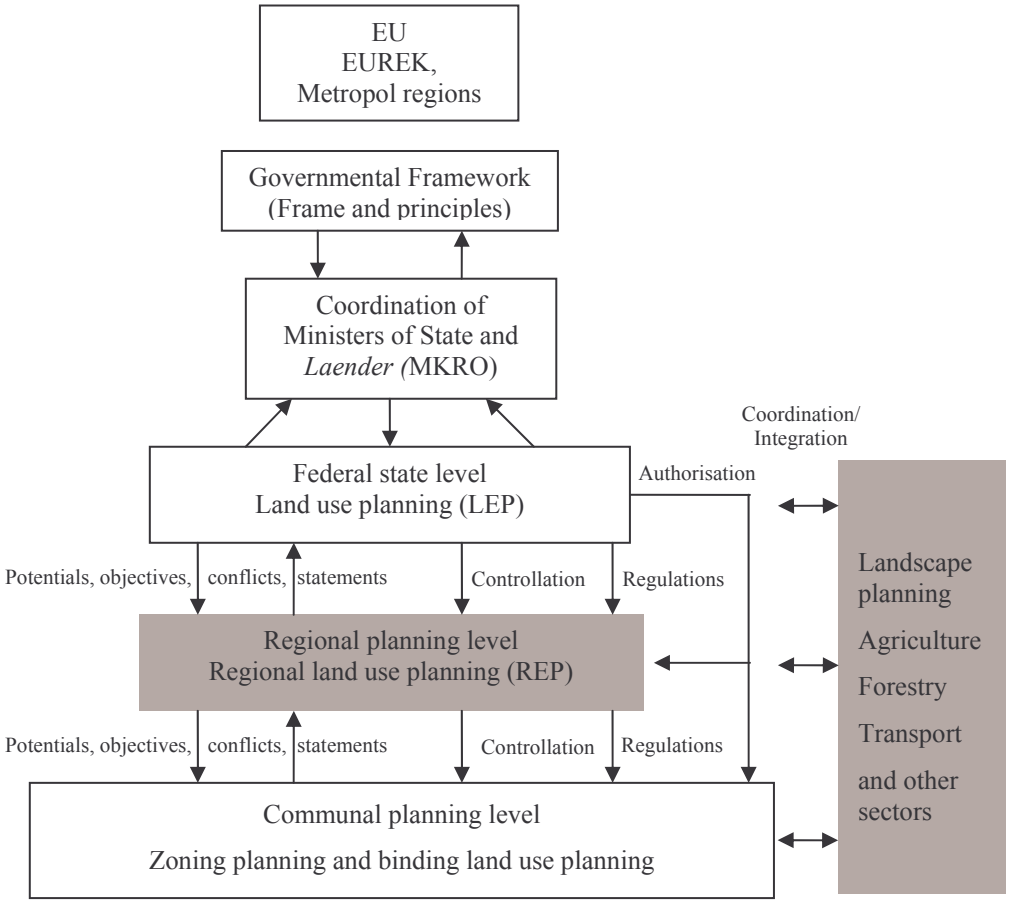

Figure 8: German spatial planning system

(Sources: modified from BfBRS 1996: 48; Fischer 2002: 47; ISL 2008)

The German subsidiary principle leaves competency with the municipalities in binding land use planning (Art. 28 para. 2 of the basic law[13] and Art. 2 para. 1 No. 1 of the Building Code and for sector planning bodies Art. 14f para. 3 UVPG). This competency has to be secured (Erbguth & Schoeneberg 1992: 52f). This fact weakens the status of regional planning, as land uses demanded by municipalities are often integrated in the report without modifications, e.g. housing areas. The strong communal land use planning in Germany results in a high degree of responsibility of the communes for the status and the development of the environmental media air and climate, soil, water, animals and plants, landscape, cultural assets as well as human health. Municipalities directly influence the usage rights of soil, water and air in accordance with their own moral concept, in order to design production and human behaviour patterns in an environmentally sound way. Therefore SEA-REP at higher tier presents a central political instrument for the warranty of a sustainable use of scarce environmental resources and the protection of the land against consumption (Scholles 1994).

[13] Municipalities must be guaranteed the right to regulate all local affairs on their own responsibility, within the limits prescribed by the law.

Box 2: Questions to be asked in tiering in SEA-REP

(Source: modified from Jacoby 2005: 28f)

Which plan regulations were already defined and assessed on a higher state land use planning level and do not require an SEA at regional plan level? → REP contents can be tiered up.

Which environmental surveys and data are already available at regional plan level for SEA-REP, which are additionally necessary? → Can data be derived from higher or lower plan level?

Which plan regulations can and should be passed on to the lower land use planning level after the subsidiary principle → REP contents can be tiered down.

The aim in SEA is an implementation of an efficient tiered system in spatial planning in the EU Member States. For making tiering fully operational, the establishment and testing of sound methodologies to perform SEA and the adaptation for EIA to the new framework of tools for environmental assessment have to be improved, according to Geneletti (2002: 33). Legally defined spatial planning systems of the EU Member States include a hierarchy of decision-making, which allows identifying the most appropriate stages to consider the impacts of actions conducted at various levels. Bunge (2003) and Bunzel (2003) describe objectives of tiering from EU policies down to project EIA. The important concept is that there are higher and lower levels of decision-making, where different strategic decisions concerning the environment are made (Lee & Walsh 1992). Information and competencies should be passed on and should be newly defined for SEA at different spatial tiers.

In the EU the top tier of Policy SEA is missing, which creates a gap in the tiered system for SEA of climate change adaptation policies, as policies set the framework for lower tiers (Chaker et al. 2006: 17). Clark pointed out in 2000 that especially the early consideration of high-tier alternatives and impacts is what makes SEA strategic, i.e. the decision on what shall be done in the future. Policy SEA would require simple and straightforward methodologies (Bailey & Dixon 1999). It would fill the gap in the tiering system for global problems, which cannot be tackled at national or regional planning level such as cumulative effects of climate change and land development. Through Policy SEA, the concept of sustainable development could be incorporated as an integral part of the development of all policies and then 'trickled down' and refined through plans to programmes, and finally to the project level (Thérivel et al. 1992; Kistenmacher & Eberle 1985: 7). In the same way objectives for an adaptation to global warming could be potentially better operationalised at the regional planning level.

2.3.4 Level of Legal Liability

The level of liability of environmental objectives influences the implementation of decisions of regional planners at regional and lower tiers. A general insufficient compliance in REP with legally-binding environmental targets and standards could be litigated (Vieten 2002: 5). It can be distinguished between three main groups of environmental standards on the basis of their origin and level of liability:

- strict legally-binding environmental standards from laws, ordinance/decree, administrative regulation, international conventions;
- political-programmatic environmental standards from political resolutions;
- scientific-technical environmental standards from (inter)national, official recommendations.

Not all tiers of a planning system, where decisions are to be made, may be connected to or even have a formal linkage to environmental assessment. Some REP contents for instance may not be binding to project-level decisions made afterwards. Thérivel (1997) and Nooteboom (2000: 156f) believed that SEA is most effective when the decisions made in a strategic plan or programme have a binding effect. Then also the objective of a reduction of the number of EIA, and time and cost of assessments at the bottom tier is most likely to be achieved. However, in any case SEA-REP can provide basic information, thus facilitating a later EIA process, whether its decisions are binding or not.

Two main groups of environmental quality objectives and environmental quality standards were analysed in the frame of this research:

- strict legally-binding protected areas, environmental quality standards, limit values and precaution-oriented guidance and threshold values;
- environmental quality objectives and environmental action objectives.

2.3.4.1 Strict Legally-Binding Protected Areas

Environmental objectives are binding through legislation (e.g. the German Nature Conservation Act), ordinance (e.g. Drinking Water Protection Ordinance), administrative regulation or international conventions, laid down as legal standards (Vieten 2002: 5; Albrecht 2008: 23f). Spatially-specific binding objectives in traditional regional planning, such as protected areas, are taboo zones or designated by statutory prohibition against environmental deterioration or degradation. Protected areas for nature and landscape, groundwater protection, recreation, bioclimate and other multi-functional uses are area-specific legally safeguarded after the EC Habitat and Wild Birds Directives, national nature conservation acts and sector laws of the EU countries.

2.3.4.2 Environmental Quality Standards

No uniform definition, criteria or legal effect exist for environmental quality standards, which are applied in many different legal systems world-wide. Environmental standards are quantitative or at least specific regulations for the limitation of different kinds of anthropogenic impacts on the environment and humans and source-related regulations. They are set from different institutions for different protection objects (e.g. human, animal, plant, water), impact factors (e.g. noise, pollutants, land uses), dimensions (e.g. in time and space) and protection levels (e.g. prevention of danger), as well as after different assessment approaches (e.g. nature-scientific, technical-economic, political-social) and with different legal obligation/commitment (e.g. from legislations to enterprises' environmental management standards) (UBA 1995).

Environmental quality standards are assessment values, which operationalise environmental quality targets, by determining for a certain parameter or indicator a specific characteristic state of environment to aim at, the measurement process and the framework requirements. In regional planning legally set standards have already passed the weighting process with economic and social aspects (Scholles 2001, 1997: 45). Environmental quality standards have therefore an important function as specific assessment criteria for the target environmental quality and definition of framework conditions for the indicators (Fürst et al. 1992: 11). Most environmental quality standards have the purpose to restrict the absorption and accumulation of noxious substances in environmental media and the human organism over environmental media of mainly soil, water and

air, food or other uses (see chap. 2.2). The scientific derivation of standards is only possible for substances and pollutants with a detectable effect threshold. The standard characterises the exposition limit below which no danger or harm is to be expected, but in the case of an exceedance of the limit an undesired effect cannot be excluded with sufficient safety (SRU 1998, 1999).

The definition, which shall be applied in this research is, that environmental quality standards are strict legally-binding limits for an environmental status which may not be infringed. Environmental quality standards set the process, value and units of measurement and framework conditions for a specific parameter or indicator. With the help of such standards environmental quality objectives can be operationalised, i.e. can be made measurable and their implementation can be examined. In the same way as the definition of quality objectives the setting of standards depends on the status of scientific knowledge and social values. Therefore these can only be set in a social clarification process and are subject to a permanent change (Fürst et al. 1992). The current discussion on effects of climate change is considered as an incentive for the setting of stricter environmental standards.

2.3.4.3 Limit Values and Precaution-Oriented Guidance and Threshold Values

Other limit values and precaution-oriented guidance and threshold values can be summarised as guidance standards. These are standards that have to be met, as they were set by an authorised body of experts such as the German Industrial Norm Institute (DIN) or in the Technical Norms for Air and Noise (TA Luft and TA Lärm) (UVP-Gesellschaft 2005; Albrecht 2008: 24).

2.3.4.4 Environmental Quality Objectives

Environmental quality objectives cannot be considered as scientifically secured standards of environmental assessment, but represent the social objectives of environmental protection for a specific area or region. They characterise a targeted status of the environment by connecting a natural scientific state of knowledge with social evaluations with the help of environmental media and protection levels. An important example for an environmental quality objective is the German target to establish and protect a biotope connection network of ecologically important areas, which shall at a minimum cover 10 % of the state territory not used for settlement purposes (BNatSchG, Art. 3) (UBA 2001).

Environmental quality objectives in form of political-programmatic targets and environmental action objectives are not necessarily strict legally-binding. They represent guidelines from mostly technical, partly politically approved plans and programmes, such as state land use plans, sector programmes, as well as environmental policy strategies or scientific recommendations without legal obligation. These objectives are set in the course of authorisation of land use plans and programmes, for instance as ordinances. As environmental quality objectives are politically and socially strongly influenced, they are subject to a permanent change (Scholles 1994).

2.3.4.5 Environmental Action Objectives

Environmental action objectives are closely linked to environmental quality objectives in relation to environmental media. An environmental action objective describes the total necessary load reduction of a pollution level (e.g. amount of emission) as a difference between the current pollution level and a maximum allowed pollution level (e.g. nitrate concentration in the environmental media groundwater). The environmental action objective indicates, which reduction

of the impacts on the environment (emission) is necessary in total, in order to achieve a specific environmental quality objective. For instance the environmental quality objective ‘stabilisation of the climate’ shall be achieved with the environmental action objective ‘reduction of the CO_2 emissions in the industrial countries by 80 % until 2050 compared to the basis year 1990’.

Applied environmental objectives and standards in this research do not present a static complete final list, but have to be extended and revised in a dynamic process through further objectives on adaptation of land use to climate change from sector laws in the future. Furthermore initial pollutions in the study region may lead to stricter and less strict regional environmental objectives (UBA 2004a). Amendments in EU and national policy influence the indicator system of SEA-REP, which therefore should stay flexible.

2.4 Regional Environmental Orientation Objectives

There is a general lack of regional environmental objectives for the protection of the land and natural resources against land consumption and the operationalisation of climate policy (see figure 5). The German higher state land use planning and strategies integrate existent national environmental objectives for spatial planning, but these often have recommending character and hardly formulate specific binding requirements for the lower regional planning. Only if regionalised environmental quality objectives and environmental quality standards are provided, will it be possible to fulfill the central task of environmental impact assessments with adequate contents (Finke et al. 2000).

Summerer (1991: 22) pointed out that “*without socially approved environmental objectives, environmental assessment lacks a normative reference basis.”* Such a reference basis is necessary, to make the transition from the descriptive specification and quantification of environmental potentials and assessment of impacts transparent and understandable for political decisions. Despite a lack of preventive regional environmental targets for the protection of land uses against land consumption, in SEA-REP the deterioration or improvement of the state of environment should be made transparent (Hennig 2006). A possibility to do this is to assess the tendency of the region’s environmental components and distance to target verbally-argumentative and to make additional scientific recommendations (Vieten 2002: 5).

The aim is to formulate regional environmental orientation objectives, which can function as guidance for regional planning authorities to set stricter targets in the future. They are outcome targets, which intend to improve the adaptive capacity of regional land uses and resources. They have the aim to integrate higher environmental policy on land protection and adaptation of land use to climate change into regional decision-making, promoting an improved adaptive capacity in a region. These orientation values are defined as recommended standards, which are proposed by a group of experts (UVP Gesellschaft 2005; Scholles 1990).

Regional environmental orientation objectives should therefore consider development potentials and the carrying capacity of natural resources and land uses, based on certain functions of areas and their current and future environmental/spatial potentials. Schmalholz (2004: 76) suggested a better consideration of the carrying capacity of the environmental media in the future. RPB will have to consider likely consequences of climate change specifically for their current state of environment

and land uses in terms of ecological changes, economic costs and social effects on their inhabitants in target setting. More should be stated on the character of spatial structures, than only a simple distribution of planning areas to the structure of the landscape, as the static adoption of landscape spatial patterns often stays without relation to the actual principles and objectives of regional planning (Finke et al. 1993). One task is to define a socially approved minimum of environmental objectives in regional plans in the form of visions. Visions play in SEA-REP especially a role in the overall assessment of the regional plan and the consideration of likely impacts of climate change and the adaptation of a region to climate change. The regional planning authority should analyse the potential of current visions of the regional plan to be adapted to climate change.

Of particular importance for SEA-REP are environmental objectives that are specifically set for the regional planning level and a specific region. Therefore the regional planning authority will have to regionalise the proposed orientation values in cooperation with environmental and sectoral authorities. SEA-REP can always only be as efficient as the available regional environmental quality concept and especially its binding character and assessment thresholds (see Finke 1996: 300). If only a few regional objectives exist, it is difficult to make a statement on the adaptive capacity of a region. It is important to integrate long-term environmental planning into regional planning, which orientates at the carrying capacity of the environment. A function of the determination of guidance minimum standards is the fixation of limits for the compensation between different targets in a region. As Gustedt et al. (1998: 49) explained, the argumentation 'I soil seal an area, but at the same time create employment' cannot be criticised when both aspects are of the same importance in the sustainability context. Therefore orientation objectives, derived from EU, German and Saxon environmental policy, indicate the potential contribution or conflict of regional plan contents to the adaptation of regional land use to climate change. LUCCA are closely linked to these objectives (table 1).
Gustedt et al. (1989: 12) recommended that "*regional planners must have the courage to set up reference or orientation values according to assumptions, which consider safety margins for the prevention of environmental harm.*" The setting of a political target or an indicator is a political process of the society, which is dynamic and never finished. This fact makes quantitative targets or standards difficult to define and to assert in political decisions (Jänicke & Zieschank 2004: 51). Anyway, in the same way as environmental quality objectives and environmental quality standards, regional orientation values can act as warning signals in case of a likely exceedance of thresholds. Development targets with quantitative guidelines with a certain time horizon cannot only be developed out of scientific knowledge, but they always imply a setting of values of the society (Kiemstedt et al. 1992; Schwekendiek et al. 1992: 11; Haaren v. 1993: 171). The objective of an efficient consideration of environmental precaution as required in Germany after Art. 12 UVPG cannot be unified with the application of most legally-binding standards, as these are generally oriented at the range of harmful effects and to a less degree at the range of precaution (Scholles & Kanning 2001: 122; Hübler 1995: 1003). Therefore regional environmental orientation objectives should implement the precautionary principle at regional spatial scale.

Table 1: Proposed regional environmental orientation objectives and derived indicators of land uses for the adaptation to climate change (LUCCA)

(Sources: BMU 1998: 54; CCW et al. 2004b: 6; EA 2006a, 2006b; EC 2007a, b; Higgins 2004; Hoggart 2004; SMI 2003b; SMUR 1997: 5, 7; WBGU 2006)

Regional Environmental Orientation Objectives	**LUCCA**
Land Uses of Importance for the Protection of Human Health and Air	
Improved quality of life and well-being: - prevented and remediated housing and industrial development on green fields in urban areas in high risk of heat stress; - reduced soil sealed area share in urban areas; - established regionalised framework for minimum housing densities; - safeguarded green and open spaces in the inner city and periphery; - improved accessibility of infrastructure, public transport and recreational areas.	LUCCA 1 – Urban areas in risk of heat stress
Improved quality of bio-climate: - safeguarded fresh air supply of initially highly polluted settlement areas from fresh air generation areas over air exchange corridors; - preserved areas of importance for the bio-climate and air hygiene against any degradation; - maintained and improved open spaces in accessibility of agglomeration areas; - safeguarded and improved flow and exchange of fresh and cold air, ensuring that urban populations can cope with air temperature extremes; - prevented new barriers and removed former barriers to air exchange; - protected and extended compact forests, particularly those sustainably managed, in the outskirts of urban agglomeration areas;	LUCCA 2 – Bio-climatic areas with relevance for human settle-ments
Improved areas for recreation: - safeguarded recreational areas in adequate density in proximity of urban agglomeration areas; - protected particularly quiet recreational areas of high landscape value; - decentralised settlement structure; - concentrated settlement growth largely on the network of spatial central places and on development axes;	LUCCA 3 – Land uses with potential for tranquil recreation in fresh air
Improved mitigation of flood risks: - state-of-the-art knowledge on effects of climate change on river flows and sea level rise taken into account in infrastructure design in coastal areas; - decreased risk of flooding of urban areas below sea water level through protection and accommodation; - managed retreat of urban settlements from endangered areas by abandonment of areas of low importance or vulnerability of land uses in favour of the protection of areas with land uses of high importance or vulnerability of land uses; - decreased risk of water pollution through flooding of industrial and commercial sites or contaminated and infill sites by sea water level rise or extreme weather events; - improved link of nature conservation with coastal protection.	LUCCA 4 – Urban areas in risk of flooding
Land Uses of Importance for the Protection of the Structure and Function of Ecosystems	
Improved ecological wildlife network and biodiversity: - improved and safeguarded large-scale connected regional wildlife corridor network for fauna and flora; - ensured integrity, coherence and connectivity of the Natura 2000 network;	LUCCA 5 – Areas with potential as refugia or

Regional Environmental Orientation Objectives	**LUCCA**
- implemented equivalent national environmental objectives of minimum area shares to be designated and protected as biotope connection network at regional level (e.g. in Germany 10 % of the national territory is strict legally-binding protected according to BNatSchG Art. 3; protection of 10-15 % of the unpopulated area of the year 1998 as ecological priority areas for the development of a biotope connection system by 2020) - conserved and restored biodiversity and ecosystem services; - maintained and restored multifunctional landscapes that provide habitat and assist migration for species; - protected habitats with regional flagship species of the flora, with potential as refugia for international, national and regional animal species in periods of extreme weather events; - protected current and potential regional migration corridors for fauna and flora; - safeguarded unfragmented areas and defined limit thresholds for an effective width of patterns of the region.	corridor of the ecological wildlife network
<u>Improved adaptive capacity and carbon and water storage of forested land:</u> - prohibited deforestation on a large scale; - strictly protected natural woodlands with high carbon stocks; - maintained previously unmanaged forested land with high potential as carbon sink; - promoted climate resilient forest management: protected and enhanced woodland habitats and associated species, safeguarded permanent vegetation cover and increased rotation periods and thinning for prevention of soil erosion, flooding, negative balance of the carbon and water storage capacity, facilitated resilience and adaptive capacity to climate change; - implemented national targets on increase of the area share of native woodland at the forested area, adapted to climate change and in conformity with the natural and geographic context of the region (not on fertile land needed for agriculture (see LUCCA 9); - achieved positive ratio (≥1) of afforested area divided through deforested area taking the level of degradation and compensation of the lost area at another place into consideration.	LUCCA 6 – Forested land
<u>Improved capacity of not forested land uses for carbon and water storage:</u> - maintained permanent grasslands, heathlands, moors and wetlands; - safeguarded biotopes with high potential for water (and carbon) capture and storage (managed forests: see LUCCA 6); - safeguarded and remediated groundwater balance in a region.	LUCCA 7 – Biotope types with potential for water capture and storage
Land Uses of Importance for the Protection of the Natural Resources Soil and Water	
<u>Improved soil protection against sealing:</u> - urban development linked to efficient public transportation infrastructure; - reduced new soil sealing by consequently challenging the area potentials of limitations of the maximum need for housing areas, prevention of urban sprawl through revitalisations of the inner cities and more efficient housing development; - promoted inner city development with urban infill of low-density residential districts and increase in relative housing density, whilst at the same time preserving important open green spaces; - contributed to a shift towards urban development on previously developed vacant land, which is currently unused and may be available for redevelopment, so called ‘brownfield sites’;	LUCCA 8 – Unsealed soils

Regional Environmental Orientation Objectives	LUCCA
- applied area-related limit values for housing for the own need of municipalities in the region and for inhabitants gained through migrations from outside; - set strict legally-binding objectives for the extent of soil sealing in the outskirts of agglomeration areas and development on brown fields; - set minimum standard for the protection of the area share of open spaces in municipalities of agglomeration areas.	LUCCA 8 (cont.)
<u>Improved soil protection for food production:</u> - strictly protected highly productive soils at high groundwater development rate against soil sealing, soil compaction and erosion; - safeguarded and increased area share for extensively managed agricultural and organically farmed land; - set aside, change from arable land to extensively managed pastures, nature conservation and biotope development on low soil productivity (link to LUCCA 5); - further extensified and adapted agricultural activities;	LUCCA 9 – Soils for high quality agricultural food production
<u>Decreased soil loss through erosion:</u> - identified areas at risk of organic matter decline; - decreased loss of soil on arable land caused by erosion; - restricted soil loss on arable land caused by erosion; - strict protection of arable land on slopes against soil erosion; - increased area share of extensively managed grassland at the total agricultural land in a region; - afforested land with priority on soils, which are endangered by erosion.	LUCCA 10 – Soils to be protected against erosion
<u>Improved water regime:</u> - ensured adequate future water supply and demand management through designation of water reservoirs; - protected water quantity of surface waters (rivers and lakes) in their catchment areas; - safeguarded and maintained groundwater development rates and levels, and the connectivity of regional groundwater aquifers; - integrated framework for adaptation measures from agriculture for the removal of agricultural drainage systems and additional reservoirs for water at lower project level.	LUCCA 11 – Freshwater resources with potential for water storage and supply
<u>Improved capacity of land uses for retention and absorption of water:</u> - natural floodplains safeguarded from all building activities; - integrated current knowledge on effects of climate change on river flows in infrastructure design; - used natural processes to the maximum to reduce flood risks e.g. working with wetlands, maximising retention capacities at source, sustainable land use and spatial planning limiting exposure and vulnerability; - prohibited construction on floodplains in unspoiled riverside landscapes; - ensured that retention areas can cope with changing rainfall patterns and intensity; - applied precautionary and risk-based approach to soil sealing in floodplains; - preserved land uses of high importance for flooding and water retention, i. e. surface waters and their natural floodplains, biotope or vegetation types with low water runoff; - preserved land uses of high importance for water storage, i. e. water catchment areas, unsealed areas and surface waters;	LUCCA 12 – Land uses with potential for retention and absorption of precipitation and inundation water

Regional Environmental Orientation Objectives	LUCCA
- safeguarded use of water bodies (for fishery, recreation, water energy, extraction of drinking water) whilst considering flood prevention, as long as avoidable impacts of their ecological functions are refrained from; - integrated mitigation zones for remediation of regulated river sections with concrete banks as recommended in water management sector.	LUCCA 12 (cont.)

Interim Targets

Objectives that cannot be achieved in a foreseeable time may contain relevant information on the status of the environment but are inappropriate for a consideration in planning processes (Vieten 2002: 5). Without a set time frame for the achievement of the regional environmental orientation objectives, which is ideally agreed upon in cooperative meetings or round tables, the motivation of the regional planning authority to voluntarily contribute to an adaptation to climate change may be potentially low. Thérivel (2004) emphasised the importance of a link of defined targets as desired end-states to specified timescales. Regional interim targets for the achievement of the set regional environmental orientation objectives should be determined for the validity time horizon of a regional plan of around 15 years for each regional environmental orientation objective. The objective of the proposed tasks to meet these interim targets is to motivate regional planning authorities to develop regional-specific strategies for the implementation of environmental policy with the help of adequate adaptation measures in a long-time period. The final target can be represented by the environmental state of LUCCA, which is aimed at under the objectives of precautionary protection and adaptation to climate change. It will have to be permanently up-dated in the future as a reaction on new policies, knowledge gain on effects of climate change and a changing regional environmental baseline.

3. Assessment Method and Process for Strategic Environmental Assessment in Regional Land Use Planning

The overall purpose of strategic environmental assessment (SEA) is to ensure that before and during the development of regional plans, environmental aspects are considered with equal weight as social and economic aspects. According to Art. 1 SEA Directive SEA shall "*provide for a high level of protection of the environment*", which means it shall ideally achieve an optimisation of the regional plan in the view of the environment. SEA-REP can thus aid in the analysis of conflicts of regional planning with adaptation to effects of climate change on the land and resources.

The assessment method and process of the core step of the impact prediction and assessment in SEA-REP can be separated into a site-specific and overall assessment of the regional plan. The site-specific assessment is referring to the method of an ecological risk analysis, which was modified for SEA-REP. It is based on environmental data and a spatial potential analysis from German landscape framework planning. An environmental indicator system was developed as a coherent concept, which includes beside indicators further components such as:

- a common understanding of the sustainability and precaution principles;
- a clear consideration of / or specific emphasis on environmental objectives;
- the targeted functions of the indicators for the assessment;
- a regional implementation context;
- operationalised assessment thresholds;
- guidelines for the assessment process;
- assessment matrices and checklists.

Further contents not studied in this research are a determination of actors and role of stakeholders and the public during the development of the indicator system (Helbron et al. 2006; Heiland et al. 2003: 202; Stratmann et al. 2007a, c).

3.1 Current Practice of SEA-REP in Germany

The analysis of German pilot projects and first regional plan amendments with integrated SEA delivered valuable recommendations for the derivation of indicators and assessment thresholds. The analysed German SEA-REP case studies include the SEA of the regional land use plan of West Saxony (Schmidt C. 2002, 2003), the SEA of the regional land use plan of North Thuringia (Schmidt C. et al. 2004), the SEA of the regional land use plan of Upper Lusatia-Lower Silesia in Saxony – transSEA (Reinke et al. 2005a, 2005b; Stratmann et al. 2007a; Helbron & Schmidt M. 2007; own experiences), the SEA of the regional land use plan Frankfurt/Rhein-Main (PVB 2006; Stock & Gründler 2004; Stock 2005), the SEA of the regional land use programme of Westpfalz (PGW 2002; Weick 2003, 2004), the SEA of the regional land use plan of Middle Hesse (RP Gießen 2006; Gerhards 2006a, 2006b) and the SEA of the land use plan of Middle Upper Rhine (RPV Mittlerer Oberrhein 2003, 2005, 2006).

During the analysis of the above case studies the applied assessment concept and method, considered environmental quality objectives and environmental quality standards, as well as derived indicators and assessment thresholds were investigated. Special attention was paid to the integration of climate change by proposal of relevant indicators. Additionally, attention was paid to the role of environmental objectives, tiering, scale and data, comprehensive nature of regional planning, integration of contents from sectoral planning and derivation of regional-specific assessment thresholds. One objective of the analysis was to find out, which different approaches of quantification exist in the selected case studies and which experience values could be passed on to other EU regions: respectively, which methodological steps could be 'standardised' in the LUCCA indicator system. The aim was therefore not a quality review of different implemented SEA[14] or evaluation of the efficiency of the applied methods. It was, instead, an analysis of existent approaches of indicators used in spatially-relevant assessments and their potential for a standardisation for SEA at regional planning level and an adaptation of land use to climate change, i.e. an identification of 'good practice'.

Although there exist many geographic, cultural and social differences in the German regions, there are also similarities of new challenges and environmental targets due to the common framework setting of the EU and Government. German competent regional planning authorities have the obligation to carry out efficient SEA of regional spatial plans, which contributes to a sustainable and precautious regional development (EU strategy for sustainable development 2001; WCED 1987; UNCED 1992; Kloepfer 2004; Kläne & Albrecht 2005). Sustainable development requires a cross-sectoral and cross-environmental factor approach, which characterises the German spatial planning system. Regional planning takes over mediation functions in order to achieve common regional-specific proposals for the solutions of problems. Some main tasks are an integrated area management and a promotion of the regional identity and knowledge of regional interrelations. However, this mediation activity is based on a relatively weak political and methodological fundament (Priebs 1999: 306ff).

3.1.1 Integration of Objectives from Sector Planning into Regional Planning

German regional planning is rather weak, if it mainly adopts and integrates demand for land from sector planning and for settlement areas from lower tiers of the municipalities without any specific modifications (Fürst 1996: 412f). In environmental policy, SEA of sectoral planning has a higher weight than SEA of coordinating comprehensive planning (Eberle 1992: 13). Due to its role as coordinating plan, a regional plan is generally not a direct catalyst of demands of the area with impacts on the environment. Exceptions are those objectives, for which regional planning takes over sector planning tasks, such as designations for urban settlement areas.

In Germany, there exists no independent sector planning 'environmental protection' or a national environmental law, but a range of different planning resorts and comprehensive spatial planning

[14] An evaluation of the quality of implemented SEA must be carried out by independent experts "*to check completeness, plausibility and adequacy of obtained environmental information*" (Hartlik 2007). This requires approved criteria, experience and objectivity.

(Bunge 1997: 10). The German environmental code planned for 2009 will be of importance for an area-wide integrated environmental planning at all planning levels and a combined assessment of SEA, habitat assessment and impact regulation under nature protection law (BMU 1998: 135; Schmidt M. et al. 2002: 363).

The independent sector planning of landscape framework planning (LRP)[15] at regional level is a key planning instrument for nature conservation and landscape management (BfN 2002: 6; Art. 5 and 13-15 of BNatSchG[16]). The instrument of landscape planning is implemented in different variations in the EU for instance in Austria, Belgium (the Walloon Region), France, Germany, Italy, Luxembourg, the Netherlands, Spain and Switzerland. It differs in terms of its legal status, objectives and scope of application. In Germany the relationship of regional planning and LRP influence the level of consideration of environmental concerns in regional planning. The common overall task of landscape framework planning is to outline and to justify requirements and measures of environmental protection and landscape management for a certain planning area (Scholles & Haaren v. 2005). This sector planning for nature conservation and landscape maintenance, landscape framework planning, gains more responsibility with the implementation of SEA-REP, as it functions as a source for environmental baseline data, regional environmental objectives and assessment thresholds for regional planning (figure 9).

LRP serve the estimation of the significance and sustainability of impacts, the formulation of compensation measures and the weighting of concerns of nature and landscape with economic interests (UBA 2001). However, classical LRP insufficiently considers the environmental media ‘climate’ and ‘global climate change’ as a cross-media topic. In LRP practice the emphasis lies on the protection of species and biotopes, recreation and impacts on landscape and landscape character.

In order to fulfil its tasks, LRP is dependent on basic data from other sector planning, as it primarily refers to the application of sector objectives. Vice-versa it formulates environmental objectives for sector planning such as agricultural planning, forestry and transport planning and gives advice on mitigations and compensations of impacts. LRP therefore functions as an important mediator between REP and sector planning. As ‘spatial environmental planning’ it aims at the multi-functionality of the landscape under the premise of sustainable land use. It assesses existent and/or planned land uses and land use patterns on their compatibility with the sustainable capacity of the natural balance and the peculiarity of the landscape and develops limits and space for the self-organisation and new structure of social and natural systems in their connection. In this process it contributes ideas for preconditions of uses, forms of land use protection, reclamation and design of the landscape and the implementation of these objectives (Haaren v. 2004). SEA ideally makes the integration of contents of LRP into REP transparent, which cannot be equated with a simple adoption, but must be understood as a translation of sector guidelines into another planning system. The transformation of LRP contents into the structure and planning elements used in REP imply a restriction on framework setting, i.e. the abstraction and generalisation of (detailed and specific) sector contents (BBR 2001).

[15] in literature also called landscape structure planning or landscape master planning.

[16] For an English translation of BNatSchG see Mulloy et al. 2001: 155ff.

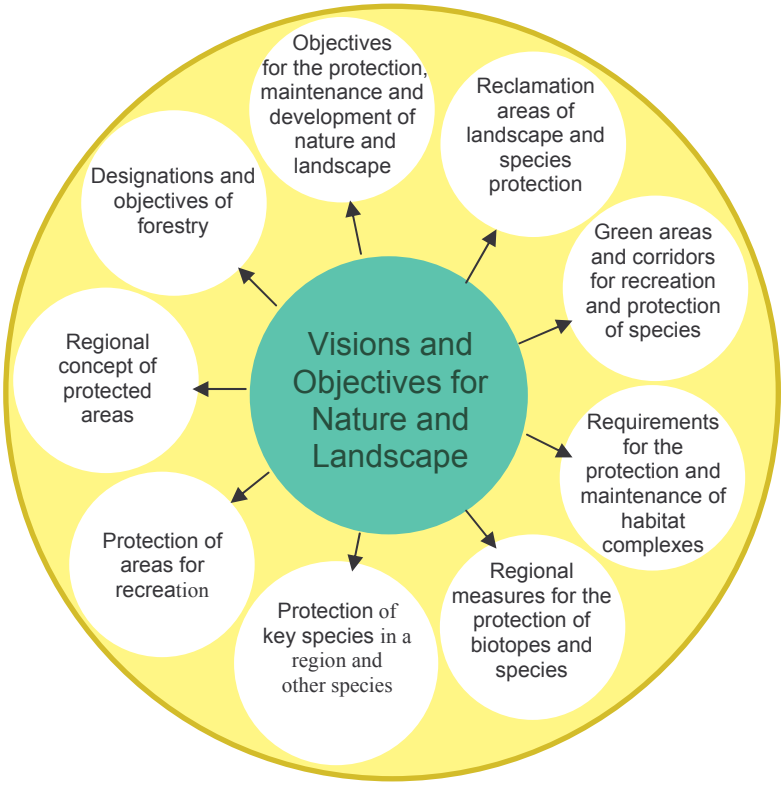

Figure 9: Contents of landscape framework plans with relevance for strategic environmental assessment in regional planning in Germany

(Source: compiled from BfN 2002; Haaren v. 2004; RPV Chemnitz-Erzgebirge 2006).

3.1.2 Weighting Process

Environmental concerns have been considered in the weighting process (also called balancing process) of regional planning before SEA was implemented in Germany. Equally in most EU Member States some form of environmental appraisal in spatial planning has been applied for a long time as a tool to solve and mediate land use conflicts, and to distribute and manage the ending natural resources and land. During this most important step in regional plan-making, decisions on principles are made by the regional planning authority with consideration of statements from authorities and the public. Land demands and objectives from sector plans and programmes such as landscape framework plans, transport development plans, forestry programmes, water management programmes and agricultural structure plans etc. are weighted with objectives of spatial planning, economic and social concerns, and are finally integrated into the regional plan. An objective weighting process ideally considers the following requirements (Hübler 1989: 80):

- the finiteness of natural resources and the often irreversible impacts, which result from their destruction or their consumption;
- the elementary importance of natural resources for human life, which are compared to other concerns less disposable;
- the limitation of the flexibility of personal liberty caused by increasing environmental burden;
- the ethic dimension of the human relationship and treatment of nature.

Art. 5 para. 2 of the German Spatial Planning Act (ROG) indicates the weighting of spatially-

important requirements and measures of LRP with other spatially-important plans and measures and their integration into REP[17]. In Germany sector plan contents become binding with their integration into the regional plan, after having been weighted against other demands for space (Art 13. ROG). Contents integrated from sector plans, which were not subject to the weighting process, are not binding objectives of spatial planning and state land use planning. Legally binding restrictions and protected areas from sector planning must be integrated into the regional plan after ROG. Art. 7 para. 3+4. ROG regulates the integration of objectives from sector plans as priority and reserve areas. A successful implementation of SEA-REP should be well linked to SEA of other plans and programmes and to instruments with importance for land management in the regions. Art. 7 para. (7) ROG determines that objectives and purpose of the protection of designated areas for nature conservation after BNatSchG and EC Habitat and Bird Directives must be taken into account. A link is to be created to the habitat site assessment, in the case adverse impacts on these areas are likely (Koch 2005).

A good relationship between regional planning and sector planning is of importance for a sustainable land use management. On the one hand a regional plan stays unsuccessful, if it makes too comprehensive individual provisions for the sector planning, as this may lead to a lack of acceptance of the individual sectoral departments. On the other hand a regional plan should not only compile sector planning requirements in a common map, but should additionally include developments in the sense of precautionary planning (Horlitz 1998: 63). Reasons for a need of changes of traditional regional planning are:

- a lack and transparency of sufficient implementation of international and national environmental quality objectives and standards at regional planning level;
- no consequent transparent documentation of assessments, which are integrated into the plan, such as results form the status-quo-prognosis of the landscape framework plan;
- planning alternatives have been often discussed within the competent regional planning authority, but the comparison of alternatives has not been made sufficiently transparent to the public.

The weighting process considers environmental aspects, but these are still often overweighted by economic or sector planning interests without sufficient transparency of reasons. German regional planning is also rather weak due to the subsidiarity principle, which means justifications of decision-making were documented, but regional planning did not much influence integrations of housing areas from lower municipalities or objectives from sector planning. Moreover cumulative impacts and compensation measures have hardly been considered in regional planning without SEA (ARL 2001: 7).

3.1.3 Transferability of a German Approach to EU Regions

Because of increasing pressures on land in the Member States of the European Union, mainly caused by abandonment and intensification of land use, land consumption and a high fragmentation

[17] The integration of LRP into REP is organised differently in the thirteen German Federal states (not Berlin, Hamburg and Bremen) and independent LPro and LRP do not always exist. The LRP can for instance be a technical statement or be primarily or secondarily integrated into the REP. LPro and LRP are not required, if a Federal state is area-wide covered by spatial plans according to Art. 7 para. 3 subpara 1 ROG.

of open space through settlement activities in the last decades, the necessity to preserve large-scale connected open areas on a regional level as well as the connection of valuable recreation areas becomes obvious (Domhardt 2005). The EU Environmental policy can function with its planning requirements as an initiator of a regional and communal environmental development planning. The duty for an integrated analysis and assessment of affected environmental concerns increases the knowledge about impacts and the weight of the concerns that are commonly subject to the weighting process (Möckel & Köck 2007: 243). The EU regional planning systems differ due to legal or administrative frameworks and historic, political or geographic reasons (figure 10). A common basis for SEA-REP are international and EU environmental and spatial planning policies, the regional planning scale, and future impacts of climate change on land use, which will affect all EU regions, but will lead to different adverse impacts at the regional level (EC 2007a).

Spatial planning as a comprehensive decision-making instrument is an important strategic intervention in European countries. Objectives of the European spatial planning (territorial agenda of the EU) are the maintenance of the variety and diversity of the European regions with their characteristic natural and cultural landscapes, to secure an existence for living, to recognise and benefit from the spatial dimension of sustainable development, and to preserve the natural resources. Beside regionalisation and demographic change, the regions have to face globalisation and international competition, have to promote growth and employment, as well as foster the adaptation to climate change and mitigation of adverse effects on the environment.

The formalised plan-making process and the integration of SEA differ depending on regulatory requirements, their liability, the type of the regional plan and SEA, time, scale and deadlines, administrative and legal regulations, the regional-specific environmental conditions, types of significant impacts anticipated and the role of the competent authority, control bodies and the stakeholders (Kirkpatrick & Lee 1999; Schmidt et al. 2004; equivalent for EIA in Lawrence 2003: 15; see for instance differences in regional planning for Poland, Czech Republic and Saxony in Reinke et al. 2005a). Such different contexts necessitate different approaches of environmental assessment (Glasson 1999: 142). The proposed SEA-REP indicator system for Germany must therefore be modified and operationalised for each EU region. The type of impact, its intensity and significance will depend on the environmental state of the region and its adaptation and mitigation strategies. Consequently the results of this investigation can only lead to such recommendations for a potential SEA-REP method, which can be relevant for all EU regions, but does not necessarily have to be relevant. Recommended orientation values of environmental objectives, LUCCA guidance indicators and assessment thresholds of this thesis must in any case be regionalised and operationalised for each specific EU region and case of SEA-REP. For the implementation of the indicator system differences of figure 10 and further criteria should be considered.

The transferability of assessment methods of the German planning systems and SEA-REP to EU regions can be justified with a common regional scale, the German formal and systematic spatial planning system, the instrument of an independent landscape planning and a good German practice of environmental integration and mitigation. SEA-REP in different EU countries has the common objective of making decisions transparent, involving the public and raising awareness.

The RPB of the European regions should modify, adapt and apply this method of SEA-REP, in order to address issues of adaptation to climate change and make the adaptive capacity and its ten-

Figure 10: Differences between EU regions with influence on strategic environmental assessment in regional land use planning.

dency in their region transparent to the public. The selected and specified indicators shall be able to adequately measure significant impacts of REP contents and their conflicts with predicted impacts of climate change on the land use and natural resources (determined as LUCCA) of the EU regions at regional planning level. These guidance indicators shall first of all apply to a broad range of environmental EU Member States' region. They will have to be operationalised regional-specific, in order to address different natural conditions and problems of a respective region.

3.1.4 Transparency, Public Participation and Awareness Raising

As required after the SEA Directive (Arts. 6 and 7) SEA-REP involves public participation in the decision-making process and transparent documentation of results and methods in the environmental report. All stakeholders are involved in an iterative SEA-REP process, which includes revision of steps, if additional information comes to light (see table A1 Annex with a proposal for Saxony). But because climate change is still often insufficiently integrated into SEA-REP no public participation in the process of adaptation to climate change is provided in SEA at regional planning level so far. Before the implementation of the SEA Directive traditional German regional planning did not satisfy the requirements of public participation, which contribute to public awareness and an improved understanding of regional development. The German Spatial Planning Act (ROG) formulates in Art. 7 para. 8 a duty for the RPB to justify its decisions in the

report of the regional plan, but the grade of compliance with environmental quality objectives was not necessarily made transparent to the public. Recktenwald (1994: 17) warned in this context: *"the fact of not making the weighting process transparent and public, opens, beside existent weaknesses of ecological concerns (on methodological grounds), door and gate for further environmental damage."*

Consequently the weighting process and its results have not necessarily been understandable for persons, who were not directly involved in the regional plan-making. Assumptions on environmental impacts were not always presented in a summarised and transparent way and were often not accessible; alternatives of REP designations and contents were insufficiently considered (see also Fischer 2002; Dalal-Clayton & Sadler 2005). The comparison of alternative sites usually took place internally at the RPB before the first draft of REP was released, and qualitative decision-making was often not documented and justified. It was not optimally recognisable for concerned persons, if and how environmental concerns were considered in the final design of REP. In Germany the public has remained rather insufficiently involved in the process of setting regional environmental quality objectives until 2008, as participation is not legally required in ROG (Schmalholz 2004: 76).

An essential goal of the implementation of the SEA-REP indicator system is an improvement of the transparency for parties concerned and especially the public during target setting and decision-making. A better integration of an open process into the plan-making allows a better public participation (Glasson 1999: 143). Societal activities at regional plan level as well as impacts of climate change affect the state of the environment. Responses to this driving force are environmental policy initiatives and strategies of spatial planning and the individual sectors (agriculture, transport, energy, industry etc.). Regional planning should include objectives and measures that society decides to set and initiate in order to counteract future unwanted changes in the state of the environment and adverse effects these may have on the ecosystems and on conditions for human life. Adaptation measures to climate change at regional planning level will directly influence regional societies and the operationalisation of EU environmental policy. It is also important to establish a transparent link between regional planning, mitigation and adaptation measures and a post SEA-REP monitoring concept (Glasson et al. 2005: 153).

An iterative and transparent SEA-REP process is required in the future, which integrates LUCCA as a response to climate change and acts at the same time as a driving force for land use changes. With data access and communication by indicators environmental assessment becomes an aiding tool of environmental policy (Walz 1997: 9). Essential components of the SEA-REP process are information, communication, participation, cooperation and mediation of all stakeholders and the public. Regional planning has the largest need for catching up in the transparent and understandable processing of the environmentally-relevant weighing material and description of assessed alternatives (Schmidt C. 2002: 46). The proposed LUCCA indicators shall contribute to awareness raising, the development of guidance documents and implementation of regional case studies, as required by the EC (2007b: 12).

3.2 Methodology of Impact Prediction and Assessment

SEA need to integrate well into the regional plan-making and public participation process (Thérivel

2004; Sheate et al. 2001; Nilsson & Dalkmann 2001). This is crucial for awareness raising on global climate change concerns and acceptance of REP designations. Standards for the administrative process including consultation and public participation are well implemented in Germany and other EU Member States (see for instance Jessel 2005; Schmidt M. et al. 2005; Uebbing 2004; Spannowsky & Krämer 2004; ODPM 2005a; Short et al. 2003; Scholles 2001; Wagner 2000; Kleinschmidt & Wagner 1998). From Arts. 4-6 and Annex I of the SEA Directive the following requirements for the assessment method of SEA-REP, which shall implement and integrate adaptation to climate change, were identified (additionally Jones et al. 2005a; Schmidt C. et al. 2004: 6; Thérivel 2004; Jacoby 2000: 471):

- preparation of an environmental report, which considers all relevant current and future environmental problems and conflicts in the region and transborder areas as well as all predicted significant environmental effects of the regional plan and their conflicts with adaptation policy to climate change;
- link of the assessment to relevant environmental protection objectives on EU, national or regional level and the way of their consideration and operationalisation;
- consideration, development and description of reasonable site alternatives, which consider the objectives and spatial scope of the regional plan and affected transborder areas;
- transparency of cumulative impacts and interrelations between REP impacts and climate change effects;
- assessment of the regional plan in a first step for site-specific impacts of REP designations, and in a second step, in an overall assessment;
- inclusion of all relevant aspects of the current state of environment and its likely development without REP implementation (the no-action alternative);
- integration of the precautionary principle into the risk assessment by providing, beside a range of danger (high risk level) and a range of optimum (low risk level), a range of prevention (medium risk level);
- consideration and implementation of potential mitigation measures at regional planning level;
- links to other plan and programmes, and identification of REP contents to be tiered up or down;
- formulation of requirements and responsibilities for more specific surveys, regulations and mitigation measures at lower planning tiers;
- links to the EC Habitat assessment.

In this research methods of project EIA were analysed on their suitability for SEA-REP (see for instance Glasson et al. 2004; Morris & Thérivel 2001; Harrop & Nixon 1999; Wathern 1995; ANL 1993). Of importance for the central assessment process is that a good cooperation between the RPB, SEA team, environmental authorities and stakeholders is achieved, if the proposed assessment method and indicator system shall be applicable and effective in practice.

3.2.1 Scope and Type of SEA Process

The SEA Directive does not explicitly require the consideration of social and economic concerns additionally to environmental impacts in SEA. As a result there exist different approaches in the EU countries depending on legislation and planning systems, which either consider environmental concerns with an equal weight as social and economic concerns in SEA-REP or put an emphasis only on environmental concerns. Two major systematic approaches in SEA are the objective-led assessment (or policy analysis inspired SEA) and baseline-led assessment (or EIA-inspired SEA)

(Sheate et al. 2001: 2; Thérivel 2004: 77). Petts (1999: 7) recommended SEA to be resource- or objective-led and to focus predictions on cumulative and indirect effects. These assessment methodologies influence the complexity, costs, efforts and results of SEA-REP. SEA-REP has to reflect upon the characteristics of the proposed regional plan and the region (scale, contents, region's area size, region's natural settings etc.) (Sadler et al. 2003). At regional planning scale of 1. 100 000 a SEA-REP may be either policy orientated (more strategic assessment), may have a focus upon a sequence of projects (site-specific assessment), or may combine both approaches.

A baseline-led appraisal demands a minimum standard of adequate environmental data. The environmental protection in Germany, which orients at environmental media, is based on a traditional science understanding, sector administrative bodies, and influenced by a strong economic interest (Hahn-Herse et al. 1984: 23f). The German EIA Act excludes social and economic concerns from EIA and SEA, and defines the environment with the help of environmental media (abiotic and biotoc biophysical factors, human health and cultural assets). As environmental concerns are often not at least equally considered in decision-making in practice, the focus in Germany remained on environmental (and directly linked social) aspects alone as demanded by Enquête Kommission (1994); BUND & Misereor (1996) and BMU (1997). Therefore, commonly applied in EA are baseline-led approaches. It is argued that the required long-term protection of the natural living basis should logically lead to a stronger weighting of ecological objectives in SEA-REP. Gustedt et al. (1998: 6) stated that "*in the past social and ecological factors were considered less and therefore it is justified to consider them stronger now.*" The equal consideration of environmental, social and economic concerns in SEA-REP implies a higher risk of underweighting of ecological concerns against economic concerns in regional decision-making. However the overall principle of German spatial planning is sustainable spatial development, which balances social and economic demands of the space with its ecological functions (Art. 1 para. 2 ROG).

The baseline-led approach puts an emphasis on potentially affected environmental media in a region. During a baseline-led assessment methodology a „*yardstick of discrete SEA themes, objectives and/or indicators is established, which is used to describe the baseline environment and identify problems, which in turn are expected to influence the strategic action objective*" (Thérivel 2004: 77). The feasibility of this method depends to a great extent on the availability and adequacy of environmental objectives, standards and data. If the aim of an efficient consideration of alternatives at regional planning level is to be achieved, further environmental objectives have to be derived for the prevention of the environment and human health against environmental harm. The consideration of information and data from landscape framework plans and other environmentally-relevant sector plans (e.g. forestry) can help to effectively minimise the necessary survey (Koch 2005). In a baseline-led approach a crucial step is the development of a geographical information system (GIS) database of all environmental media on the one hand, and human activities in the region on the other, including initial impacts, current status and future forecasts. The analysis of the regional environment should be carried out for each specific situation and should be based on current existing scientific research and knowledge about the region. The final SEA report has to document this information and data gaps. It should also recommend future tasks for improvements of a proceeding sustainable region (Partidário 1996).

This is different in other EU Member States, where a rather sustainable approach in SEA is striven

for [e.g. sustainability appraisal in the United Kingdom (Glasson & Marshall 2007: 228ff) or SEIA and e-test processes in the Netherlands (Sadler & Verheem 1996; Tonk & Verheem 1997)].

In the objective-led-assessment methodology sustainable objectives for the strategic options are first developed and then indicators selected, which test whether various alternatives achieve the strategic action objectives (Smith & Sheate 2001a). The approach is inspired by analytical techniques, which are applied in policy analysis and strategic planning processes (e.g. EC 2005b). Objective-led appraisal can be applied at the very early stages of the regional plan formulation, creating early links between SEA and regional plan-making. The approach enables evaluation of consistence of REP with the relevant environmental objectives of each sector, and enforces the issue of public participation at the planning and formulation stage. It influences the identification of plan objectives and a possible review of these objectives within the overall strategic alternatives of the planning process. An objective-led appraisal thus provides early input into formulation of strategic alternatives, but it can be applied only if sufficiently well formulated environmental, health or sustainability objectives exist for the respective region. This approach also enables only general evaluation of initial alternatives of the REP and needs to be later complemented by detailed assessment of detailed alternatives of plan designations (Sadler et al. 2003). The problem with adaptation to climate change by SEA-REP is that required regional environmental objectives are often still missing.

Dalal-Clayton & Sadler (2005) suggested combining the impact assessment approach with the objective-led appraisal, in order to achieve a good practice SEA. The two processes combined help to strengthen SEA by building on their individual strengths, and ensure that the merits of both approaches are combined to ensure adequate coverage.

In this study a baseline-led site-specific assessment is combined with a strategic overall assessment of the regional plan, where cumulative impacts are considered (Helbron & Schmidt M. 2007; Reinke et al. 2005a, 2005b; Stratmann et al. 2007a; PVB 2006). In a baseline-led approach a consideration of impacts required a link of the indicators to the planning area of the region. In an objective-led approach, which is more strategic and closer to Policy SEA, the distance-to-target of sustainability objectives such as the transborder cooperation with a neighbouring state in the field of flood prevention and control can be assessed. The SEA-REP assessment method should combine baseline- and objective-led approaches by determination of regional environmental orientation objectives on the one hand, and selection of environmental state indicators on the other. Figure 11 shows this two-tier-assessment method for SEA-REP.

Subject to the site-specific assessment are spatially relevant designations of REP, which set a framework for EIA at lower level or which require a habitat assessment (after EC Habitat Directive). Subject to the overall assessment is the entire normative part of the regional plan, i.e. the entire designations, objectives and principles, except the explanatory statements (Jacoby 2005: 28). The emphasis in this thesis lies on the site-specific assessment.

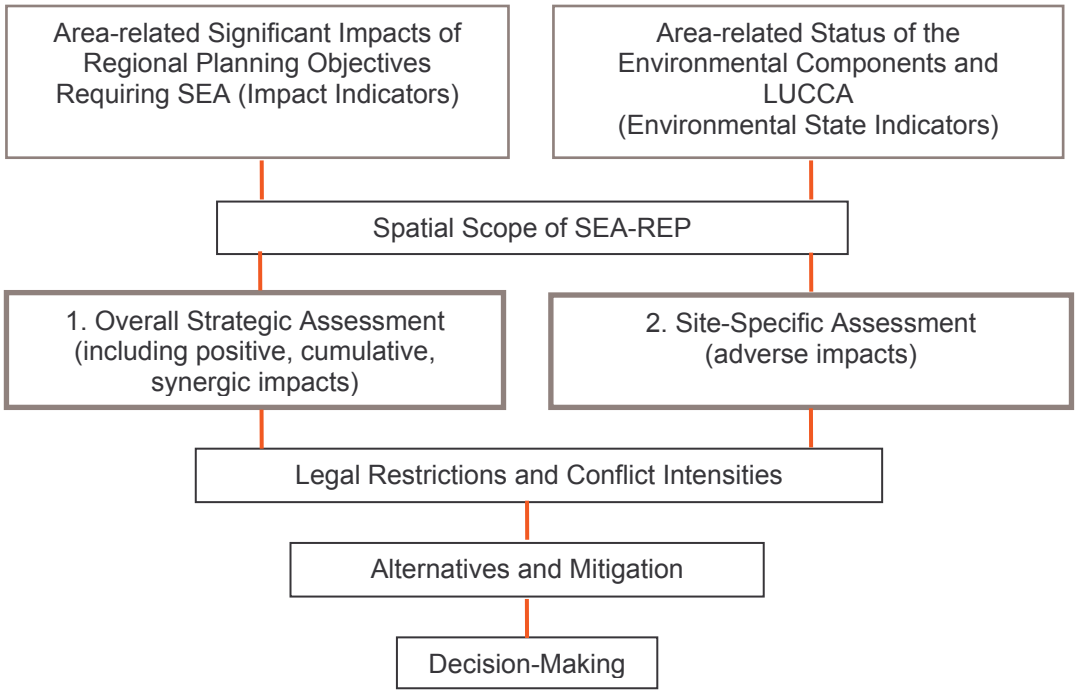

Figure 11: Two-tier-assessment method for SEA-REP

3.2.2 Assessment Process

The proposed assessment method for SEA-REP, including an indicator system, matrices and checklists, shall represent a regional 'decision support system', which assists regional and sectoral planners in setting priorities for adaptation measures, and in specifying regional environmental targets. The RPB has the task to identify in the scoping step in consultation with authorities and stakeholders significant impacts of REP contents, the site-specific importance (sensitivity and value) of each state indicator, as well as to determine impact zones. The RPB has to establish the baseline environment and compile an environmental objective system consisting of relevant international, national and regional environmental protection objectives, specifically for the region and SEA-REP. The assessment method includes precautionary values, as it is based on the assumption that an early framework for priority setting during the designation of zones for land or resource use, which are either very vulnerable or resilient to climate change, will save money and time. Regional planning shall initiate a support system for all sectoral systems, which, in parallel and under revision, have to develop their approved adaptation systems. The following process was applied in the assessment:

1. definition and cross-linking of all spatially relevant impact factors related to the respective regional plan designations;
2. cross-linking impact factors with environmental components/LUCCA;
3. pragmatic definition of standardised potential impact zones, i.e. a proposal of the spatial scope of impacts for each development category, which has to be specified case-by-case;
4. sector expert assessment of the state of the environment according to its importance and impact-specific sensitivity;
5. derivation of assessment thresholds and ordinal conflict classes for the impact assessment;

6. development of checklists for each environmental component/LUCCA;
7. site-specific assessment of environmental impacts of REP contents on their conflict intensity on the affected area and impact zone (conflict map);
8. comparison of alternatives and implementation of mitigation measures;
9. overall assessment of the impacts of the regional plan.

Standardised checklists for each environmental component address the following issues:

1. definition of the environmental component;
2. documentation of the relevant environmental quality objectives and environmental quality standards, particularly regional environmental orientation objectives;
3. definition of the state and impact indicators;
4. methodological derivation and proposal of thresholds for the assessment of the state of environment to be regionalised;
5. determination of a classification of the environmental conflict intensity;
6. description of potential positive impacts;
7. proposed mitigation and adaptation measures;
8. contents for tiering.

For the selection of LUCCA, the link between REP impacts and effects of climate change were analysed, with the aim of identifying land uses of special importance for adaptation to climate change. The analyses create the basis for the development of a quantitative indicator system, including:

1. derivation of quantitative indicators and assessment thresholds for LUCCA and the mitigation of likely adverse environmental effects of climate change;
2. discussion of prerequisites for the operationalisation of the module LUCCA in a region.

3.2.3 Methods for Impact Prediction and Assessment

The SEA Directive, German EIA Act and Spatial Planning Acts leave the choice of methods for SEA-REP open to the RPB. It needs long-term practical experience to come to results, which methods can be effectively applied for the prediction and assessment of environmental impacts at strategic level (Jessel 2005; Eriksson 2002). The selection of the assessment process has to be made very carefully, as the method strongly influences the quality of the result of the assessment and its contribution to the decision-making. It also infuences the acceptance of decisions in public and the legal conformity of the application for the ordinance of the plan (UVP-Leitstelle Bremen 1996: 59).

Impact prediction is a technical exercise as part of the SEA scoping process, which creates a link between regional planning objectives and area designations on one side, and the sensitivities and value of the environmental state of the affected area and impact zone on the other. It utilises environmental baseline data in order to estimate the characteristics, spatial occurrence and conflict intensity of impacts. An effective assessment in SEA requires beside efficient techniques and methods, a formal transparent process and sufficiently deep knowledge on the environmental baseline and future regional developments (NERI 1999). The impact prediction and cross-links of REP contents, impact factors and affected environmental components can be supported by matrices. In this approach, future effects of climate on land uses were linked, with the help of state indicators, to impact factors, which were identified for land use degradation in impact prediction.

The application of EIA methods at the strategic level is to a great extent influenced by less detailed environmental data and information about the development, leading to difficulties in predicting site-specific impacts. Therefore, beside a few quantitative values, often broad qualitative impact assessments and prediction, often deduced from scenarios of possible future development, are necessary (Bunge 2001). Aspects such as scale and accuracy of the contents of the regional plan build the framework for the analysis of adoptable EIA methods. The methods have to be slightly modified for application on the strategic level of assessment, especially with relevance to impact identification and prediction of cumulative impacts from multiple sources, description of baseline conditions, selection of indicators and assessment thresholds.

Impact assessment is the central task of the environmental impact statement (EIS) in EIA as well as SEA. The procedural step of the impact assessment represents beside the selection of alternatives the 'core module' (Peters 1995; George 2000) and the 'core problem' of EIA (Bechmann & Hartlik 1998). In environmental assessment "*objective of the assessment is the evaluation of the environmental-related permissibility under aspects of prevention of environmental damage*" (Scholles 1997: 194). An evaluated judgement is required, no statement of facts. At the same time the assessment shall be comparable, understandable and verifiable (Albert et al. 1998). Therefore the impact assessment in SEA-REP should first of all clearly separate and make transparent the type of assessment steps being of relevance for SEA-REP in the environmental report:

- the sector expert assessment, which is part of the potential analysis, of the state of the environment according to its importance and impact-specific sensitivity: this assessment method takes place in Germany for each environmental media separately in sector-specific authorities, and is compiled and evaluated for the region by landscape framework planning. Experts of the different sectors specify the framework created at regional planning level at lower land use planning level;
- the assessment of environmental impacts of REP contents on their conflict intensity on the affected area and their conflicts or cumulative effects with adverse effects of climate change: this assessment lies within the responsibility of the RPB as part of SEA-REP.

Impact assessment can only be applied once the main activities in the proposed REP become clear (Sadler et al. 2003). Draft alternatives of REP must be site-specifically formulated with their type, location and time of construction, in order to compare alternatives. This fact makes SEA-REP not effective in guiding the generation of alternatives. The assessment process rather involves a comparison of the status-quo and likely changes of environmental components including LUCCA, with their defined target-status on the affected area and impact zone. The selected state indicators create a link between the REP contents and their implementation on the area.

For SEA-REP assessment methods are adapted from existing methods, for instance from sustainability appraisals, political decision-making processes, ecological risk analysis or EIA, and are modified in order to meet the requirements of SEA at the higher more abstract spatial planning level. In practice, SEA has to fight with different serious methodological problems. Not only will *one* SEA methodology apply to all regional plans in the EU. Scholles & Kanning (2001: 121) emphasised, that "*the real method*" for environmental assessment does not exist, but rather a variety of methods and method mixes, from which selection can be made in reference to the characteristics of the affected natural area, the type of development or designation, the environmental data and the expertise of the environmental consultant. Brown & Thérivel (2000: 185) suggested setting up "*an array of SEA tools from which the appropriate one(s) can be selected*

to meet the needs of particular circumstances". For SEA, taking place at an abstract planning level, a large range of tools such as checklists, matrices, causal networks or scenarios can be recommended (Thérivel 2004; Lee & Wood 1995).

3.2.4 Environmental Conflict Analysis

As it is not possible to simply adopt EIA methods to SEA, a specific methodological framework was applied in this research, which meets the needs of the more strategic and abstract level of regional planning. The applied assessment method was derived from the German ecological risk analysis originally developed by Bachfischer (1978), amended by Scharpf (1982), Kiemstedt et al. (1982), Hoppenstedt & Riedl (1992), Scholles (1997, 2005). This method has traditionally been used and further developed in the German practice of EIA for a long time. This method is adequate for assessments under a high level of uncertainty. It was thus modified and incorporated into SEA-REP. Missing data and information is replaced by expert judgements or different scenarios. The environmental conflict analysis applied in SEA-REP shall identify, classify and assess environmental impacts on the region's state of environment. Results shall help regional planners to make decisions, which represent the best option from the perspective of the environment, and to avoid environmental conflicts or, if that is not possible, include mitigations at an early planning stage, before the draft REP is developed. For its application in SEA-REP the classical risk analysis was modified, mainly due to less detailed information on impacts and the broad scale of the regional plan designations.

3.3 Spatial Effects of Climate Change

Potential effects of climate change on the European regions' natural resources will be caused directly and indirectly through a predicted increasing average air temperature of up to 6°C under different scenarios of increase of carbon emissions by 2100, a rising sea water level by 10-90 cm, more regular and more intensive heavy rainfall and floods along rivers, summer droughts and heat waves (IPCC 2007b; BMU 2007b). Hurricanes and storms as well as natural disasters and hazards will accompany these changed conditions (see Fleischhauer 2004 on the integration of natural hazards into spatial planning). The spatial effects of climate change in the European regions will vary widely, mainly depending on the local climate, soil and vegetation types or precipitation patterns in different geographical locations. The tendency was forecasted for a precipitation increase in Northern Europe, whereas Southern Europe will be affected more frequently by droughts (EEA 2007a; EC 2007a: 4).

A region's adaptive capacity will reduce or increase as a result of the initial pollution and degradation level of the natural resources, their natural ecological stability and already implemented adaptation measures (see chap. 3.3.2). Particularly vulnerable to climatic change are low-lying areas close to the coast and in river catchments, mountainous areas, and areas with high risks of increasing numbers of storms and hurricanes (EC 2005a: 7). Most European regions will have to deal with direct or indirect effects of changes of the atmosphere and climate of (EEA 2004; EC 2005a: 12ff):

- an average air temperature increase;

- heavier precipitation events causing larger scale flooding events;
- droughts and summer heat waves;
- extreme weather events such as storms;
- increased or decreased annual river discharge;
- more regular and intensive river floods;
- soil erosion and degradation;
- changes of plant phenology and distribution of plant and animal species.

3.3.1 Most Vulnerable Areas and Land Uses in Europe

General future scenarios for the development of the climate in Europe represented the basis for the integration of spatial effects of climate change into SEA-REP (figures 12 and 13).

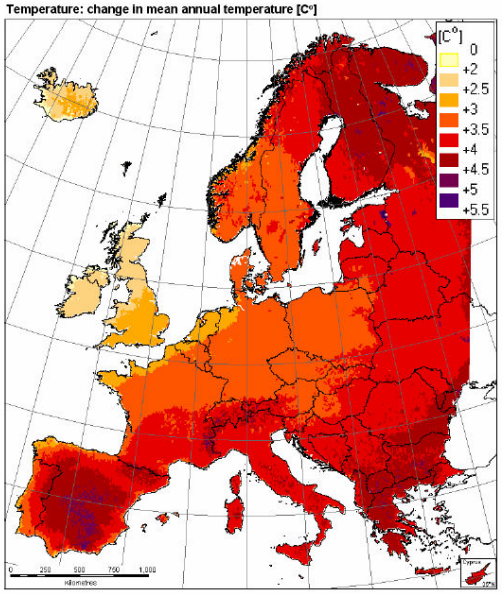

Figure 12: Change in mean annual temperature by the end of this century

(Source: EC 2007b: 7)

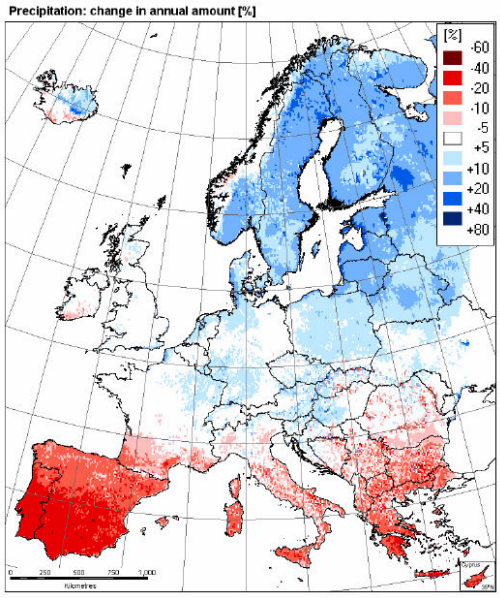

Figure 13: Change in mean annual precipitation by the end of this century

(Source: EC 2007b: 8)

Southern and South-East Europe

Southern and South-East Europe and the entire Mediterranean Basin, where freshwater resources are already scarce, will be most affected by water scarcity, droughts, heat waves, forest fires, biodiversity losses, soil and ecosystem degradation, and eventually desertification (EC 2007a: 5, 16; 2007b: 9).

Western and Atlantic Europe

For Western and Atlantic Europe extreme events such as violent storms and floods are projected to become more frequent, also more heat related deaths particularly in urban agglomerations are expected (EC 2007a: 5; 2007b: 9).

Central Europe

In Central Europe precipitation would increase mainly in winter, while there would be reductions in summer (EC 2007a: 5; 2007b: 10).

Northern Europe and Arctic Region

In Northern Europe conditions will be similar to Western Europe, but with more change in temperatures and precipitation. Much more precipitation is expected and a larger part in the form of rain instead of snow. Earth temperature increases are likely to be higher in the Arctic Region than anywhere else on earth, resulting in accelerated melting of ocean and land ice, and thawing of permafrost (EC 2007a: 5; 2007b: 10).

Coastal Zones

Coastal zones are affected by a global sea-level rise of up to 80 cm compared to pre-industrial levels; by 2100 this will be combined with more frequent and intensive storm tides. Coastal erosion, coastal flooding and underground salt water intrusion will change the shape, hydrology, biodiversity and land use of coastlines (EC 2006; Smeddinck 2006). Intrusion of seawater into sweet water bodies and the groundwater will cause a spread of marshland.

Low-lying areas and river deltas are most at risk of flooding. Increasingly endangered and negatively affected are inhabitants of urban areas in coastal zones, which are often of high importance for tourism. Almost 50 % of the European population lives in the 50 km coastal strip; 85 % of the Dutch and Belgian coast, and 50 % of the German coast, has less than 5 m elevation (EC 2007a: 5; 2007b: 11). It is assumed that the annual costs for mitigation actions including the artificial remedy of beach erosion in the EU will rapidly increase in the future to an average of 5.4 billions Euros in the time period of 1990-2020 (UNIPCC 2002; EC 2004: 4, 68).

River Basins, Floodplains and Water Resources

River basins and floodplains will be more frequently and intensively flooded, which is the costliest natural catastrophe in Europe, as many built-up areas, infrastructure, industrial and power generation plants are close to rivers. More intense precipitation will influence the frequency and intensity of river floods, soil erosion, and water pollution, and cause changes to ecosystems. Basins with increased volume or intensity of precipitation and runoff are expected to face more nutrient losses and erosion, with negative impacts on aquatic ecosystems, e. g. eutrophication and algae bloom (EC 2007a: 5; 2007b: 11).

Mountain Regions

Mountain regions, in particular the Alps, will be characterised by the thawing of snow and permafrost and the retreat of glaciers, which will reduce the water supply of mountains and increase run-off. Consequences are a disturbance of river flows and an increase of risks of floods in winter and spring through higher quantities of inundation water and water scarcity in summer (EC 2007a: 5; 2007b: 11).

Water Resources

Increasing aridity will affect the allocation of water, and will reduce access of the society to safe drinking water in Europe (EC 2007a: 4; EA 2006a, 2006b). Regional water resources are a mixture of river flows, water captured from rivers, stored in lakes and reservoirs and water pumped up from natural groundwater aquifers beneath the ground. Particularly the need for irrigation water in agriculture will increase in Southern European regions. Other regions will be affected by higher rainfall, flooding rivers and sometimes higher groundwater levels. The inundation water could flush pollutants out of landfill sites, contaminated land and abandoned mines, and harm the water quality. In some regions shallow water bodies will more likely eutrophy in summer due to higher evaporation losses.

In many European regions the groundwater regime is to a large extent anthropogenic impacted. The groundwater levels decreased, because of agricultural drainages, water abstraction and other developments such as open-cast mining activities. This initial harm will increase the significance of climate change effects on regional water resources. For instance preserved wetlands are very sensitive to aridity, but are themselves of essential value for freshwater and carbon storage (WBGU 1998). In more arid European areas with an increase of the average evaporation and transpiration, wetlands will also be affected by greater per capita water demand and accumulation of nutrients from agriculture. If they dry out, the ecosystem will change, greenhouse gases will be released and their water storage function will be lost.

Urban Settlements and Recreational Areas

The well-being of people living in urban areas at coasts or large rivers will be increasingly endangered by flooding, which will also have economic effects. More frequent flooding of rivers and sea water-level rise will lead to a necessary abandonment of settlements in floodplains and at low coastal areas. Increasing average temperatures and local urban heat islands will lead to heat stress, reduced working capability and an increased mortality rate in urban areas, and a general higher need of human populations for fresh air and recreation (EEA 2004). Urban populations will have to be adequately supplied with fresh and cold air (CCW et al. 2004b: 6).

Agricultural Land

Some low-lying coastal land will certainly be abandoned to the sea, or become impossible to farm as salt water invades the soil and groundwater. In Great Britain for instance "*half the grade 1 agricultural land is below the 5 metre contour and much of it could be lost to sea or salt*" (EA 2006a). Particularly Eastern European regions are facing an increasing risk of droughts and soil degradation. Further negative impacts on agriculture might be higher risks to loss of yield through pests, diseases and natural hazards, change of agricultural habitats and biodiversity.

Some North European regions will benefit from increasing temperatures and longer vegetation periods by increasing crop yields in areas with sufficient water supply (EEA 2004). At the same time sprawling cities threaten to consume the best agricultural lands, displacing agricultural activity to both less productive areas (requiring higher inputs of water and fertilisers) and more remote upland locations (with increased risk of soil erosion). In addition, the quality of agricultural land that is not urbanised but in the vicinity of sprawling cities has also been reduced (EEA 2006: 31).

Forested Land

Effects of changed air, soil and water conditions in forested land will accumulate with forest communities, disturbances and management methods of the forestry sector (EEA 2005b: 19). Tree species compositions are to different extents vulnerable to increasing air temperatures. Often monocultures of not native tree species are highly endangered by damage through storms or pests (Kölling 2006). Forests function as sink for heavy metals, which they filter out from polluted air and pass on to the organic layers of the soil and the groundwater. As a result European forest soils accumulate heavy metals such as chrome, lead or copper and are also in danger of acidification.

The forestry sector has to adapt to climate change as well as contribute to a mitigation of GHG emissions, as trees "*act as a net sink for atmospheric CO2, absorbing some of the emissions from burning fossil fuels*" (EEA 2005a: 69). Currently, most of the world's forests are absorbing more carbon dioxide than they release due to fertile air and forest management. The share of GHG reductions however is predicted to be rather small with around 1 % of emissions from fossil-fuel burning annually in 2010 (EEA 2005a: 82). However this might be a temporary solution, as the way how terrestrial ecosystems exchange CO_2 with the atmosphere can easily change. If temperatures further rise and wooded ecosystems cannot adapt anymore, but break down, they could within decades release the CO_2 they stored before into the atmosphere (EEA 2005a). In the EU a target is more carbon-conscious forest management, similar to soil management in terms of both mitigation and adaptation (EC 2007a: 18).

In Europe the tendency is a slight increase in woodland[18] area with native broad-leaved trees, but most new plantations are still managed forest with short rotation times[19] and of coniferous tree species, primarily spruce (*Picea abies*) and pine (*Pinus sylvestris*). Such monoculture plantations of coniferous trees are of limited biological diversity value and can impact adversely on the rural landscape (EPA Ireland 2002: 48). Forested land dominates in the Baltic States, Germany, Scandinavia and Slovenia. A major current activity in the EU Member States is afforestation mainly on abandoned agricultural areas.

In Central Europe native mature broad-leaved species such as beech and oak trees have the highest potential to accumulate carbon, even under a limited increased heat stress. For instance in Bavaria in South Germany natural and semi-natural beech woodlands (*Fagus sylvatica*) can in the best way adapt to climate change, whilst the non-native spruce forests (*Picea abies*) are highly endangered (Kölling 2006). In Germany, deforestation is strictly legally prohibited for any forested land with an area size above 2 hectares according to the German Forestry Protection Act (BWaldG) and federal legislations. The preservation of forests and afforestation areas are integrated from forestry plans as priority areas in German regional plans. Increasingly important will be ecologically managed forests, but currently parallel to an increase of the area share of forests in Europe, the intensity of management and harvest is generally increasing (EEA 2005a). In conformance with the cultural and natural vision for a landscape, native woodlands should be extended, due to their

[18] Woodlands are defined as natural or nature-close, self-organised and self-regulated, ecologically stable systems with a high dynamic (Ellenberg 1996: 112).

[19] Managed Forests are defined as not self-organised, but planted and managed, not self-regulated systems, which species composition did not stabilise (Ellenberg 1996: 316). The term forest is used for both managed forests and woodlands.

multiple benefits for nature and landscape, their potential for precipitation water storage, and as a temporary CO_2 sink.

Areas for Nature Conservation

Climate change will potentially change the composition of species and will lead to shifts of habitats from the Southern to the Northern parts of Europe. The level of stress on certain plant and animal species will increase. The environmental media of fauna, flora and biodiversity covers biotopes, ecosystems and habitats for plants and animals. Fauna, flora and biodiversity have to be prevented from loss of species and habitat types, with the overall objective of the protection of the variety, peculiarity and beauty of nature and landscape (Art. 1 BNatSchG). Additional to negative stress of a changing climate, REP designations lead to intensification of land uses, land consumption and fragmentation of natural habitats, unfragmented areas and linear biotope connection structures.

Overview of Environmental Effects

Table 2 lists examples for likely spatial effects of climate change and their accumulation with site-specific regional plan designations. Presented examples of cause-effect-receptor relationships are subject to a high level of uncertainty, have to be specified case-by-case, and monitored. The existing conflicts constitute an urgent need for an implementation of spatial adaptation targets, regional-specific information on future effects and the potential role of legal and administrative responses at zoning and building code planning levels.

Table 2: Environmental effects of climate change and regional land use plan designations and adaptation measures

(Source: compiled from EEA 2004, BMU 2007b; CCW et al. 2004b: 5; EC 2007a, b; EC 2005a)

Core Problem or Negative Effect of Climate Change	**Regional Spatially-relevant (Cumulative) Impacts**	**Affected Natural Resources and Land Uses**	**Mitigation and Adaptation Measures Integrated into Regional Land Use Planning**	**Information Needs**	**Legislative and Administrative Reponses**
Cause or source	Effect, pathway, interrelations	Receptor	Response		
Degradation of forested land; coniferous monoculture	- decrease/loss of biodiversity - carbon release from soil - decreased water storage capacity	- woodlands and forests - natural woodland to monocultures - afforestation sites	- protection of woodlands and forests for cold air production, recreation, carbon and water capture and storage - afforestation	Integration of ecological management into designnations from forestry	Natural and plantation forests Deforestation is prohibited
Soil erosion and degradation	- loss of fertile top soil - subsidence and heave could worsen, as clay dries out with high aridity and wets with high moisture - decreased soil productivity	- agricultural land and food - forested land - natural ecosystems	- integration of agricultural sites of most productive soils, which are protected against urban sprawl	Soil and climate maps Land use map	Cross compliance Legally-binding protection of productive soils against erosion
Land consumption	- loss of soil, water and carbon sink - increase of air temperature	- unsealed soil - open areas, green belts	- desealing	Soil sealing map tiering	Strict legally-binding restriction of land consumption
Increased flood risk in floodplains and coastal area	- soil erosion - flooding of natural floodplains - overtopping and failure of flood defences along rivers and streams - low infiltration rates combined with high surface run-off	- human beings and infrastructure in urban settlements in floodplains or in areas below future sea water level	- floodplains and other retention areas - restricted urban development in floodplains or below sea water levels - areas for relocation and resettlement - extending current flood protection zones - future-oriented coastal management	Flood risk maps 'Population at risk' maps Land use maps	Zoning guidelines and Building codes Assessment procedures
	- flooding - contamination	- industrial and commercial sites	- no industrial areas in floodplains or below future sea water levels		

Core Problem or Negative Effect of Climate Change	**Regional Spatially-relevant (Cumulative) Impacts**	**Affected Natural Resources and Land Uses**	**Mitigation and Adaptation Measures Integrated into Regional Land Use Planning**	**Information Needs**	**Legislative and Administrative Reponses**
Cause or source	Effect, pathway, interrelations	Receptor	Response		
	- loss of agricultural area - intrusion of seawater; salinisation - spreading of marshland	- agricultural land in coastal zones	- agricultural land, crops and livestock		
Increasing aridity and increase of evaporation and transpiration	- Release of greenhouse gases - Lower river flows and decreasing water quantity of water bodies in summer	- wetlands	- renaturation - rising groundwater level - retention areas - desealing	Biotope types map	Strict legally-binding restriction of land consumption
	- temporary drying out of small rivers and shallow lakes - dehydration of water bodies - decreasing groundwater level - drinking water scarcity	- freshwater resources	- preservation of drinking water catchment areas - watershed management - no change of water balance or soil sealing in catchment areas with harm of groundwater development rate	Water management maps	supply of freshwater resources, floodplains
	- irrigation water scarcity Decreasing groundwater level - soil degradation - salinisation of irrigated soils; spread of crop pests - decline of yield	- agricultural land and food production	- hedges for wind protection - alley cropping	Soil maps	Adaptation of irrigation erosion measures
Increasing summer heat	- heat islands, high ozone levels - higher morbidity and mortality caused by heat stress - intensity and affected area of	- human health, living quality and well-being in urban areas - cities of high	- prevention of warming of urban air - land use designations for greenhouse gas reduction, capture and storage - protection of urban green spaces and	Urban climate maps, Population affected maps	Zoning Guidelines, Building Codes, Assessment Procedures

Core Problem or Negative Effect of Climate Change	**Regional Spatially-relevant (Cumulative) Impacts**	**Affected Natural Resources and Land Uses**	**Mitigation and Adaptation Measures Integrated into Regional Land Use Planning**	**Information Needs**	**Legislative and Administrative Reponses**
Cause or source	Effect, pathway, interrelations	Receptor	Response		
	urban, industrial or commercial sites on green fields in the outskirts of cities and agglomeration areas (urban sprawl) adds to increasing inner-city temperatures	settlement density - highly polluted urban areas	fresh air corridors - preservation of climate protection areas, cold air generation areas and fresh air corridors - desealing and remediation of brownfields - preservation of open spaces, recreational areas offering shelter and fresh air		sanitation of anthropogenic influenced areas (desealing, renaturation etc.)
Biodiversity	- land consumption, fragmentation and degradation of water regime - stress to vulnerable ecosystems - shift of habitats, species migration or extinction - human recreation causing disturbance of species and damage to habitats	- flora and fauna and their habitats	- nature reserves and sanitation areas for nature and landscape - regional biotope connection network of wildlife habitats and corridors	Affected vulnerable species and habitats Potential improvement of biotope connection network	Habitats and Wild Birds Directives (Natura 2000) Nature Conservation Act
Transport and energy efficiency	- decrease of groundwater level, change of groundwater regime - loss of vegetation, woodlands	- areas for exploitation of near-surface non renewable resources - renewable energy production - transport infrastructure	- ensure qualified densities, compactness, mixture of uses	Energy-use profile maps Urban structure maps Transport Modes	Building Codes, Assessment Procedures, Transport Management

3.3.2 Implementation of Adaptation Measures: Regional Planning for Land Use Change

Current information on regional-specific spatial effects of climate change, sensitivities and carrying capacities of existent and future ecosystems or land uses may be scarce or uncertain. The exact level of human-induced temperature increase is uncertain and will also depend on global mitigation action taken over the next few decades. However, sufficient knowledge on the type, significance and time dimensions of impacts is important for the setting of priorities for land use planning. Despite high uncertainties of predictions, stricter protection of natural resources against degradation and an early adaptation of regional land uses are a better option, than later reactive un-planned responses to increasingly frequent crises and disasters (EC 2007a: 9).

Negative effects of climate change will intensify the current and future anthropogenic progressive physical degradation of natural resources and land use. Climate change is thus "*one of the most significant and complex cumulative effects*" (CCW et al. 2004b: 3). For SEA-REP two types of impacts were distinguished, which are a result of man-made impacts of regional development, acting together with effects of climate change:

- constraints set by climate change on a regional plan as part of the environmental baseline, requiring adaptation of land uses;
- effects of a regional plan on future emissions of greenhouse gases as part of the impact prediction and assessment, addressing the mitigation potential of regional plan designations (see chap. 2.2.2).

An adapted and efficient land management (e.g. extension of ecologically managed forests as carbon sinks) could complement climate change mitigation (gtz 2007: 4). Regional land use planning should provide an integrated decision-support framework, which links vulnerability and risk assessment with adaptive capacities, and adaptation responses with the aim to facilitate the identification of cost-efficient measures – also at lower tiers (EC 2007a: 20). Land use changes induced by climate change will influence future regional planning, as the adaptive capacity and vulnerability of environmental factors will have to get stronger consideration in decision-making. The following definitions of the Intergovernmental Panel on Climate Change (IPPC 2007a: 869ff) are a basis for this research:

- vulnerability as the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity;
- adaptation as the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities;
- adaptive capacity as the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences;
- sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate variability or change.

Planning for land use change as adaptation measure should ensure the regional supply of drinking water, flood protection, agricultural food production, and prevention of health of the human

population, whose need for recreation in fresh and cold air will increase and diversify. Adaptation aims at a reduction of the vulnerability of regional natural resources or land uses and an increase of their resilience and thus adaptive capacity to the effects of climate change (EC 2005a: 7; ODPM 2005a). Regional land use planning has mainly to be in charge of measures for the prevention and mitigation of:

- heat stress in urban areas, which is intensified through land consumption and pollution;
- flooding of housing areas or industrial sites, which are situated in floodplains or coastal zones below sea water level.

A central method to increase the adaptive capacity of existent natural resources and land uses is to further increase their ecological carrying capacity. "*Healthy ecosystems will be more resilient to climate change and so more able to maintain the supply of ecosystem services on which our prosperity and wellbeing depend*" (EC 2007a: 17). A future integrated environmental or sustainable regional land use management must therefore consequently reduce human pressures that cause fragmentation, degradation, over-exploitation and pollution of ecosystems (EC 2007a: 17). The German demand for an area-wide 'ecologisation' of regional land use planning was in the past always accompanied by weighting conflicts (Finke 1996). „*Ecologically-oriented spatial planning (...) is in itself not new, but has been rather neglected due to a preference of economic concerns*" (Fürst 1986). Nowadays comprehensive spatial planning still requires a stronger ecological orientation, due to ongoing environmental pressure on the environment, and particularly area-wide physical depletion of the environmental media, outside of strict legally-binding protected sites (e.g. Hübler 1981; Fürst 1996: 414ff; Kiemstedt et al. 1993: 14ff). The objective of an increased carrying capacity puts an emphasis on the prevention of impacts, instead of reaction to hazards. According to Succow (2006, 2008a) the protection and maintenance of intact natural ecosystems, which function as carbon sinks, storage for water, generation of cold air, productivity and increase of biodiversity etc., must have priority in all forms of land use. However, regional planning is not free from restrictions and requires a change of political-administrative conditions to be able to implement important changes such as responses to climate change. A main problem is, that regional land use planning still often lacks the courage to argue offensively with the sectoral planning in order to bring about necessary changes more powerfully (Fürst 1986: 4). As regional planning integrates and weights adaptation objectives and measures from all sectors, it should assess their cumulative impacts with effects of climate change in the overall strategic assessment of SEA-REP. The area-wide, cross-sectoral integration of ecological aspects in regional land use planning still needs to be improved. The adaptation to climate change requires a common effort of spatial planning together with all sectoral planning, determining spatially-relevant objectives for the EU regions. Dahl (2002) believed that it is essential (in the EU) to find coherent ways to regulate and adjust the behaviour of states and regions in a common interest. With the aim to reduce land consumption and physical degradation of natural resources the cooperation between regional planning and sector planning (particularly transport planning, agricultural planning, forestry and water management) must be further improved.

SEA-REP with LUCCA is considered as a new driving force for the strengthening of regional planning and for an area-wide improvement of the integration of environmental concerns into decision-making. The aim is an optimisation of the regional plan from the perspective of the environment. João (2005) emphasised, that SEA must improve, rather than just analyse a plan or

programme. A best practice model is considered as an iterative SEA-REP approach, which implements EU adaptation policy, applies key LUCCA indicators, and proposes target-oriented adaptation measures. The overall objective is to preventively designate land uses with a high potential of their carrying capacity and ecological functions for the mitigation of carbon release and/or adaptation to climate change. It is widely accepted that an integration of environmental concerns only in parts of human activities is not sustainable in the long term.

The forthcoming launching of a German national environmental code in 2009 (currently a first draft proposal of the Ministry of Environment is available: BMU 2008) is a response to a federal reform at national level, which might initiate a new discussion on the need for an integrated environmental guidance planning (formerly initiated by Hahn-Herse et al. 1984; Hoppenstedt 1993: 7f; Erbguth 1996). Additionally, other legislations such as the SEA Directive and planning instruments should integrate adaptation to climate change and should be accordingly modified on the basis of new challenges and problems to be faced in the future.

3.3.3 Environmental Baseline Data

Of crucial importance for the regionalisation of the LUCCA indicators will be the availability, actuality, accessibility and quality of data on the changing state of the environment under influence of climate change in the EU regions. The quality and efficiency of SEA-REP and its results very much depend on environmental data, which shall be derived from current knowledge and generally approved assessment techniques (Art. 5 No 2. of the SEA Directive; DIFU 2004: 24). A minimum requirement is the analysis and evaluation of existing surveys gathered in maps and databases. Moreover in SEA-REP, already available predictions and data on a future state of the environment with a changed climate, effects on land use and land cover, should be applied. Further issues defined by SEA-REP objectives should come before data collection (João 2007: 489). Revised or new environmental surveys and data on the vulnerability of areas, and the potential of current land uses for adaptation to climate change will be required. Regional data registers could contain brownfields, retention areas designated for river flooding, nature conservation and landscape protection areas, areas for agriculture and forestry and compensation areas (Seuss 2000: 22f).

An environmental baseline analysis[20] has to be carried out in order to identify, describe and evaluate the current state of environment together with the future environment without the strategic action, i.e. implementation of the regional plan contents. Regional-specific information will be needed on the effects of climate change on all environmental components including LUCCA, if a high quality SEA-REP shall be achieved. Special focus shall lie on the vulnerability, adaptive capacity and mitigation potential of the environmental components of a region. A vulnerability assessment of regional land use and mapping of vulnerable areas in flood risk maps in accordance with the types of impacts will be necessary (EC 2007a: 11).

In Germany landscape framework planning provides together with existent national environmental data systems a major part of the necessary area-wide information on the environmental baseline of a region (see Jessel 2005, Scholles & Haaren v. 2005; DIFU 2004: 36). The LRP delivers

[20] Methods of landscape assessment are discussed in detail by Köppel et al. 2004; Wulf 2001; Bastian & Schreiber 1999.

designation zones, environmental objectives and assessment thresholds for species, biotope and landscape protection for SEA-REP (Haaren v. et al. 2004, Scholles & Haaren v. 2005). As regulated in Art. 13 BNatSchG, LRP has the task of assessing and presenting for the entire region the area-wide status, conflicts and objectives for the development, protection and maintenance of nature and landscape including the environmental media species and biotopes, soil, water, climate and air and landscape. Global climate has been mainly considered as one of the natural resources in landscape planning with focus on the preservation of local bio-climatically important areas, fresh air corridors and cold air generation sites of valuable function for human health in urban settlements and recreational sites. It delivers an environmental baseline analysis of landscape and nature of a region and thus strongly supports SEA-REP[21]. In the future it will have to integrate more consequent global climate issues by assessing areas on their

- future suitability, i.e. the capacity and functionality of natural area potentials, mitigation potential;
- future sensitivity, i.e. characteristics of the potential such as carrying capacity limits, adaptive capacity, buffer capacity or rarity, and
- initial pollution and cumulative impacts, i.e. change of potential compared to its original capacity also under effects of climate change.

Potential new designations of landscape framework planning might be priority areas for LUCCA, their maintenance, management and development towards more ecological land uses.

3.4 Site-Specific Significant Impacts of Regional Planning

The first task in the scoping step for the site-specific assessment of SEA-REP is to identify regional plan contents and objectives, which cause area-related likely significant impacts on the environmental components (SEA Directive Art 3 (5); Annex II). In the site-specific assessment an emphasis was put on "*direct spatial effects in the sense of area-related designations*" (MKRO 2004: 7). A direct comparison of alternative sites requires a spatially-specific evaluation. At this point of time in the SEA-REP process clearly structured plan objectives in form of planning categories should be available.

In this early step the RPB should come to an agreement with all concerned authorities and stakeholders on the subject, scope, level of detail and investigation methods to be applied in SEA-REP (see for instance Sommer 2002a; Bunge 2002; Hendler 2002). The scope and level of detail of the SEA-REP as well as the choice of methods should be adapted to the process and if necessary revised in the course of the SEA-REP (MKRO 2004: 5). In scoping public and scientific concerns – which might arise during implementation, operation and/or determination of the proposed development – should be identified and evaluated in order to determine important issues and parameters that should be addressed in an environmental impact statement (Glasson et al. 1999). These include concerns of a soon and effective adaptation of regional land uses to climate change.

[21] LRP themselves are subject to SEA, although their main objective is to formulate objectives for the protection and maintenance of species and habitats of nature and landscape with likely positive effects for the environment (Art. 1 para 1 and 2 BNatSchG). Different authors debated on this decision, which shall not be discussed in detail in this survey (for detailed information see Mönnecke 2003; Schmidt C. 2003; Haaren v. et al. (2004); Haaren v. et al. 2000; Scholles (2001); Scholles & Haaren v 2005; Jessel et al. 2003; Schmidt M. et al. 2002: 362f; Dressler 2004: 12f).

The best practice contents of the scoping step, explained below, should serve as guidance for RPB, indicating which significant impacts require site-specific assessments of proposed site alternatives. The ultimate aim is to mitigate the assessed conflict intensity by either choosing another feasible location or by implementing mitigation measures.

3.4.1 Designation Criteria and Objectives

The German regional planning is regulated after the national Spatial Planning Act (ROG) and the federal land use planning acts. The main principles of sustainable spatial development (Art. 1 para. 1 ROG) are defined in Art. 2 of ROG:

„The spatial plans shall contain provisions for the spatial structure, especially for:

1. *the settlement structure aimed at,*
2. *the open space structure aimed at; this can include*
   a) *large-scale cross-regional open spaces and open space protection,*
   b) *land uses in the open space, such as locations for the precautionary securing as well as controlled search and extraction of site-specific resources,*
   c) *remediation and development of spatial functions,*
3. *locations and routes for infrastructure, which shall be secured.“*

These principles of spatial planning are general guidelines for the development, organisation and securing of the space for the subsequent spatial weighting or discretion decision (Art. 3 ROG). An essential aim is to reduce disparities between agglomeration areas and rural structurally weak areas. Further in the ROG, all land uses, whose concerns and interests have to be considered in the weighting process are listed, if they are relevant for the regional land use: recreation, leisure, culture, agriculture and forestry, nature, social and technical infrastructure, settlement development, transport, defence, economy/service sector/commerce, housing etc.. These various land uses and demands for space indicate the challenge regional planners are facing during the REP plan-making and weighting process. Art. 7 of the ROG defines objectives and principles as minimum contents of spatial development plans according to their level of obligation for the planning authorities (see box 3).

Box 3: German REP principles and objectives

Principles have to be considered according to Art. 3 No. 3 ROG by planning authorities as spatially-relevant planning and measures in the course of the weighting process or in a case-by-case decision provided by Art. 4 ROG and for further applicable regulations for planning and measures.

Objectives have to be adhered to, as defined in Art. 3 No. 2 ROG and required in Arts. 4 and 5 ROG, for binding spatially-relevant planning and measures, which have been subject to the weighting process. Objectives concerning binding land use planning constitute a duty for conformance by the municipalities as formulated in Art. 1 para. 4 German Building Code (BauGB).

The main difference between these two REP contents is that principles will be further subject to weighting processes, whilst objectives have already undergone a weighting process and are binding guidelines in form of text or graphic regulations in the regional plan and report for the development, order and safeguarding of space (Art. 3 ROG).

German regional planning is an original state task with the aim to intensify the cooperation between state land use/regional planning and communal planning (ARL 1998: 2f). It is organised in different ways in the federal states, but its common tasks are to:

- prepare sub local, supra-sectoral, summarizing, long-term comprehensive development plans;
- coordinate all spatially-important measures and aim at an optimal development of the region and an optimal spatial structure;
- intensively examine sector planning objectives and take over a coordination and mediation function to guide different and competing demands for utilisation and space by looking ahead in an environmentally sound way (UBA 1999: 33)[22].

Box 4: German regional planning instruments

The decentralised concentration is a spatial model, with the aim to counteract a strong spatial concentration of infrastructure, employment, inhabitants etc. on a main centre by strengthening several central places. It is an important principle for a balanced and functioning spatial and settlement structure, aiming at the strengthening and development of a net of central places and the regional self-forces in regions far from agglomeration. A one-sided promotion, limited to a few growing regions, shall be avoided (UBA 1995).

A central place is a city or municipality, which was designated to have a specific function in the central-local system. It therefore takes over specific supply tasks for the population within its integration area, well connected to the supra-local transport net, beside its supply facilities of the resident inhabitants. Depending on the type and dimension of the integration area, it can be distinguished between small, lower, medium and upper centres. Settlement areas within city boundaries and suburbs in large agglomeration places are designated. The state land use plan designates upper and middle centres, the regional plan lower centres.

Axes are characterised by a concentration of transport and supply arteries (linear infrastructure) and by a sequence of settlements of varying density. They are divided into connection axes, settlement axes and development axes depending on their main function (SMUR 1997: 43).

Open spaces are areas outside of settlements, where landscape or ecological functions shall be developed.

Green corridors and green belts have the main objective to prevent from urban sprawl and provide recreational sites and air exchange. Sub-regional settlements of higher density and with higher settlement pressure are structured through connected regional green corridors as open spaces. Urban sprawl can be also limited by priority areas for nature and landscape, agriculture or other land uses.

Settlement areas are one or several parts of municipalities, in which the urban activity shall take place with priority beyond the municipalities' own development (sub local development) or with the purpose of a concentration of the municipalities' own development.

Priority areas are areas, which, owing to the requirements of regional policy, a certain task takes priority over other tasks, and in which all plans and measures with spatial implications have to be compatible with the purpose that has priority (Art. 7 para. 4. No. 1 ROG; SMUR 1997: 45).

Priority areas may be defined in structural planning where local or regional structural requirements dictate that a particular function (e.g. recreation, nature/landscape, mining, urban expansion) shall have priority on that area. Any planning or action must be compatible with this priority purpose (UBA 1995: 50). They are partly integrated from sector planning. Priority areas are designated for:

- agriculture, to protect high productive soils and the open countryside against urban sprawl;
- climate protection, to provide urban areas with fresh air;
- safeguarding of resources such as sand, gravels or lignite;
- the protection of species and habitats;
- safeguarding of existing forests and afforestation sites;
- safeguarding groundwater occurrence;
- recreation, leisure and tourism and
- flood protection.

Reserve areas are earmarked for a particular use but will not be utilised until it is required (UBA 1995: 55). Its functions or uses shall gain special weight in the weighting process with other competing spatially-relevant land uses (Art. 7 para. 4. No. 2 ROG).

[22] for further information see BBR, spatial planning, under http://www.bbr.bund.de (in German).

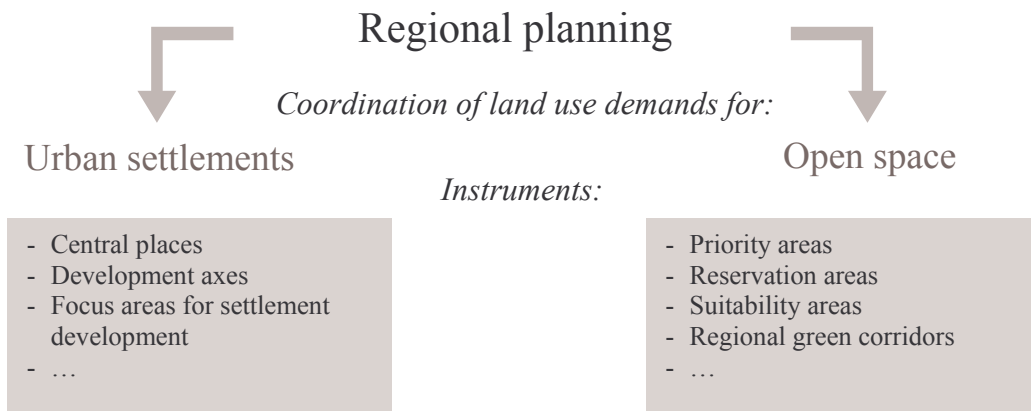

Figure 14: Regional planning as state task

(Source: adopted from SMI 2004: 15)

Box 4 and figure 14 present classical regional planning instruments after Art. 7 para. 2 ROG. The designation of priority areas in German regional planning is a good example for a strong objective, which has been weighted, decided and was integrated into the spatial overall concept of the regional plan. Priority areas can especially well consider values to be protected and development possibilities of individual natural area potentials in their connectivity above the local level. Regional plan designation criteria should be assessed in the overall assessment of a regional plan in SEA-REP.

3.4.2 Significant Impacts of Regional Plan Designations

The SEA team and competent authority specified the scope of the assessment, i.e. which regional plan contents are i) to be assessed on specific sites, ii) to be assessed in the overall assessment and iii) not subject to SEA. REP contents are defined in this study as the entirety of all objectives, principles and designations of a regional plan. REP objectives are defined as binding contents of the regional plan. REP principles are understood as contents of the regional plan, which were not subject to the weighting process. REP designations are defined as spatial zones and linear structures documented in the maps of the regional plan. Priority areas are consequently both objectives and designations.

The scope and detail of SEA-REP analysis are limited to likely significant environmental impacts (Art. 5 No. 1 of the SEA Directive), which are relevant for the weighting. According to Art. 5 of the SEA Directive the likely significant impacts and reasonable alternatives shall be identified, described and evaluated in the environmental report. The significance criteria defined in Annex II of the SEA Directive should be discussed and approved in the scoping hearings and documented in the environmental report (Petts 1999: 9). In SEA-REP the significance of a conflict is relevant, but it is not possible to come to a result of what is allowed and what is not allowed as in EIA, due to a high level of uncertainty, except if legal restrictions are of concern (Stock 2005). This limitation results in a certain flexibility of the regional planners in scoping during the determination of the level of significance of impacts and the following categorisation of regional contents being subject to SEA. However from the experience of EIA, significance does not have to be viewed as an

absolute threshold for environmental assessment (see for instance Lawrence 2003: 35). On the contrary the RPB has the flexibility to go beyond legal and planning requirements during the identification of those impacts, which shall (not must) be assessed in SEA-REP.

It was determined that those contents of the regional land use plan require a site-specific SEA, which are directly linked to the area and set the framework for EIA projects, listed in Annexes I or II of the EIA Directive 85/337/EEC, or which require an assessment pursuant to Article 6 or 7 of the Habitats and Wild Birds Directive (SEA Directive Art. 3 para. 2 a, b). Regional plan contents, not within the competency of the regional planning authority, were passed on to SEA for other spatial or sector plans or programmes (tiering) (see chap. 2.3.3). Figure 15 shows further criteria, which can be used in the step of the identification of REP contents to be considered in the site-specific assessment and the overall plan assessment of SEA-REP.

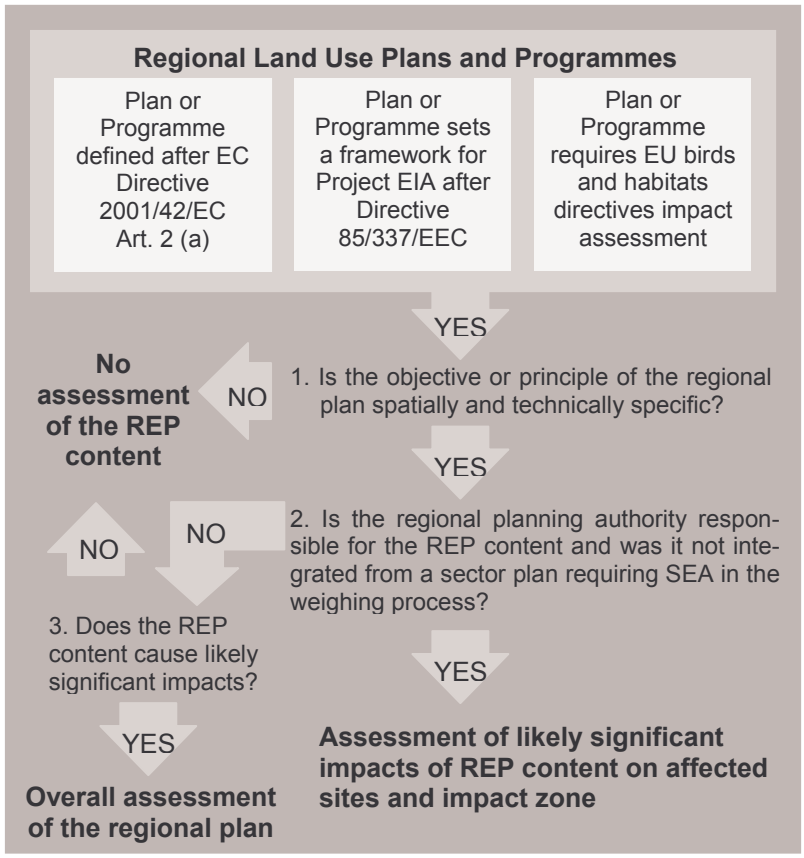

Figure 15: Scope of the site-specific assessment in strategic environmental planning in regional planning (SEA-REP)

(Source: modified from Schmidt et al. 2004; Reinke et al. 2005a; PVB 2006)

In Germany particularly site designations for spatially-relevant developments after Art. 7 para. 2 subpara. 3 ROG, as well as priority areas, reserve areas and suitability areas according to Art. 7 para. 2 subpara. 4 ROG are of relevance (see also Grotefels 2006: 25). Integrated contents and objectives of sector plans are excluded from SEA-REP on individually affected areas, as they do not have effects of control or legal obligation (Spannowsky & Krämer 2005: 51 cit. in Grotefels 2006: 26). However, the RPB should clarify, that these are assessed in the SEA of the specific competent sector authority. It is recommended to consider all significant impacts of integrated

sector contents in the overall strategic assessment of the regional plan, no matter if a framework for EIA is set. However, the determination of significance can be subject to some constraints and limitations in the SEA-REP implementation:

- judgements of the importance of impacts may be difficult, as intensities of effects are unknown at the scale of regional planning;
- selection of thresholds (significant – significance unclear – insignificant) is influenced by the uncertainty of predictions;
- the quality of the process and methods applied to determine significant impacts depends on the expertise of the planners;

The RPB should be aware that the determination of significance may have far-reaching consequences for decision-making. For LUCCA it means a high conflict with climate policy.

REP Contents Subject to Site-specific SEA

The most relevant site-specific REP designations in Germany with likely significant impacts and framework setting for EIA or EC Habitat or Wild Birds Directive are (Jacoby 2004; Helbron and Schmidt 2005a):

- new urban settlements;
- industrial and commercial sites;
- areas for the exploitation of near-surface non renewable resources;
- tourism areas;
- areas for measures of technical flood control and protection;
- areas for the use of water resources;
- areas for renewable energy production, i.e. wind energy power plants or areas for biomass production or further spatially-relevant privileged projects in the countryside;
- safeguarding of routes for infrastructure and social facilities such as holiday sites and large-scale leisure parks, transport and supply routes (not integrated from sector planning);
- sites for the extension of forests, i.e. afforestation sites (integrated from sector plan);
- electricity power supply lines.

The impacts of these designations and their designation criteria have to be assessed in SEA-REP. Regional planners have to assess case-by-case, if a site-specific assessment and a comparison of alternative locations is required.

Priority areas for agriculture cause significant negative and positive impacts on the land and natural resources at lower project level, as agricultural activity directly affects most environmental media. An evident positive effect in the context of adaptation of land use to climate change is its safeguarding function for the land in the outskirts of agglomeration areas against urban sprawl. However, a priority area for agriculture does not necessarily set a framework for EIA projects such as mass breeding installations or irrigation projects (see also Schmidt C. et al. 2004). Therefore a case-by-case decision on the intensity of the assessment is necessary at lower planning level. In SEA-REP negative impacts of this area designation are considered in the overall assessment of the plan. The safeguarding of certain land uses by integration into REP, e.g. the designation of a priority area for agriculture or green corridor with the purpose to restrict urban sprawl, does not improve the current state of the environment on these areas. It can be debated whether these

safeguarding designations should also be assessed as positive assessments in the site-specific comparison of alternative sites.

REP Contents Subject to Strategic Overall Assessment of the Regional Plan

Impacts of REP designations, which are not directly linked to EIA or habitat assessment, were considered in the overall strategic assessment of the regional plan. Measures to protect open spaces such as green corridors are not obligatorily subject to SEA-REP (ARL 2001: 6), only, if they create a framework for EIA as planning instruments, which influence indirectly the designation of housing sites. However, they can have positive impacts, as they prevent from urban sprawl. Designations, which partly set a framework for EIA projects are (Jacoby 2004):

- central places;
- settlement and transport axis;
- special municipality functions;
- orientation values for housing spaces in municipalities;
- regional green corridors and priority areas for protection of open spaces, recreation etc.

Positive effects of the remediation of mining sites following the closing down of a pit were not considered in the overall assessment in transSEA. These designations first of all mean a complete loss or degradation of the affected environmental component on the area and impact zone, which is assessed site-specifically. Due to the long time lag between mining operations and the remediation of sites, positive effects cannot be covered by the current regional planning horizon. The remediation of sites can later be considered in the SEA of the following REP draft version.

Road by-passes around towns or villages are presented in the regional plan in form of a symbol in proximity of an urban settlement. They are integrated from sector transport planning, but have immediate effects on urban settlements. Their positive and negative effects have to be considered in the overall assessment. The site-specific assessment of a road by-pass around a town or village is recommended to be tiered to transport planning at communal land use planning level. Due to its symbolic presentation without specific relation to the area, significant environmental impacts cannot be predicted at programmatic regional planning level. At the lower transport planning level the final alignment of the road will be determined.

DIFU (2004: 51) do not support a site-specific SEA for plan contents and objectives, which have the sole purpose to secure the status quo. However, further contributions of regional planning to the protection of the environment and remediation of initially polluted environmental components are recommended to be considered in the overall strategic assessment of SEA-REP, such as designations of:

- strict legally protected areas;
- areas for nature and landscape (species and biotope protection);
- areas for safeguarding of the regional ecological biotope connection network;
- areas for nature and landscape (landscape character and perception);
- areas of landscapes in need of remediation and areas of landscapes with special requirements for their use (e.g. prevention against flooding, prevention from wind or water erosion);
- open space functions in potential flood development areas;
- regional areas for safeguarding of woodland;

- areas for the compensation or substitution of unavoidable impacts on the natural regime or landscape character at another site;
- areas for the protection of soils with special functionality;
- areas for the remediation of soils, which are significantly impacted in their functions;
- areas for the remediation of contaminated soils;
- fresh air and cold air generation areas and corridors;
- settlement areas of historic value (e.g. protected minority).

The overall strategic assessment should also answer the question to which extent environmental policy of adaptation to climate change has been implemented in REP. The balance of the process and change of the regional land use and resources indicate the chances of the region to mitigate the level of harm of adverse effects and hazards of climate change in the future.

REP Contents not Subject to SEA-REP

Not all contents of a regional plan can be assessed according to their impacts on the environment. For instance, too abstract or imprecise settlement concepts, or designations of functions to municipalities may be spatially and in contents not specific enough to create a link to future EIA or EC Habitat or Wild Birds Directive and significant impacts. Additionally, the SEA Directive does not legally require the assessment of all REP contents. The SEA Directive omits national defence, civil emergency, and financial or budget plans and programmes from SEA in Art. 3 para. 8. Therefore a REP content ‘priority area for military’ can be excluded from SEA-REP in the EU. Examples for informal REP contents excluded in transSEA from SEA-REP are designations of functional spaces, objectives for transborder cooperation or the general objective for mediation of the use of alternative energies in a region.

3.4.3 Impact Factors of Physical Degradation

At the level of regional planning, impacts cannot be predicted or assumed in much detail, as the real land uses and activities are not finally regulated in the regional plan. Subject to SEA-REP are mainly significant impacts of the facility and operation phase (Schmidt C. et al. 2004). Quantified predictions on the intensity of land uses in terms of settlement density or quantified water abstractions are not possible due to the scale and lack of data. With the aim to categorise all significant impacts of REP contents, impact factors were identified, which cover all predicted significant environmental impacts of the site-specific contents of the regional plan. These impact factors can be used to detect negative and positive (increasing and decreasing effect), additive and cumulative effects of REP (Annex I lit. f of the SEA Directive). They can be transferred to nearly all SEA-REP in the EU regions and can function as guidance for impact prediction in SEA-REP. Each impact factor characterises likely loss or alterations of the environmental state of the environmental components and LUCCA of a region. Impact factors aggregate and abstract more specific significant impacts likely to occur due to subsequent developments at EIA level. They have to be operationalised for each specific regional plan and the significant impacts of its contents.

An adverse impact leads to a harm or complete loss of an environmental component or its environmental functions in the future. Conflicting designations of REP may lead to impacts, displacements or restrictions of current land uses. If LUCCA are affected, a conflict occurs with

regional environmental orientation objectives for an adaptation to climate change. Significant negative impacts of REP designations will, in combination with adverse changes of land uses caused by climate change, likely lead to accumulating problems affecting the environmental components. These will influence the living quality of humankind in a region in the long term (see chap. 3.3). Box 5 lists impact factors for SEA-REP. Positive impact factors are represented with a reduction of land use pressures, e.g. desealing of areas or a remediation of the groundwater regime.

Box 5: Impact factors for SEA-REP

(Sources: Helbron & Schmidt M. 2007; Stratmann et al. 2007a; PVB 2005, 2006; Schmidt C. et al. 2004; PÖU 1999)

Impact Factors	Code	Explanation and Quantification
Of Regional Relevance on the Affected Site:		
Land consumption (land take)*	Lc	Soil abstraction or soil sealing; Quantified and assessed on the affected site in square kilometres or hectares.
Land use change#	Lu	Change of function of the area without soil removal or sealing; e.g. afforestation, recreational use; Quantified and assessed on the affected site in square kilometres or hectares.
Fragmentation/ Barrier effect	F/B	Separation of functions, effects on accessibility of areas; Quantified and assessed in cutting length in kilometres and rest area shares in square kilometres or hectares; additional number of crossings of rivers, wildlife or air corridors etc.
Additionally of Regional and Transborder Relevance on the Impact Zone:		
Change of water balance	Cw	Groundwater level increase or decrease; Quantified and assessed by the sensitivity of the affected site and impact zone including catchment area in square kilometres or hectares.
Directed flooding	Fl	Targeted anthropogenic flooding of areas; Quantified and assessed by the sensitivity of the affected site and impact zone including catchment area in square kilometres or hectares.
Noise	N	Potential exceedance of noise standards or general increase of noise level; Quantified and assessed by the sensitivity of the affected site and impact zone in square kilometres or hectares; additional number of inhabitants affected by noise in a settlement area.
Disturbance	D	Disturbance of animals. Quantified and assessed by sensitivity of species occurrence, e.g. Red List of endangered species.
Pollution	P	Potential exceedance of pollution standards or increase of pollution risk; Quantified and assessed by sensitivity of the affected site and impact zone in square kilometres or hectares.
Visual impacts	Vi	Aesthetically effective impacts on the landscape character (change of peculiarity, variety and natural characteristics); Quantified and assessed by sensitivity of the affected site and impact zone in square kilometres or hectares.

Impact Factors	Code	Explanation and Quantification
No Direct Link to the Area, but Considered in the Overall Strategic Assessment of the Regional Plan:		
Sewage and waste production	W	Change of waste production in quality and quantity in the region; Tendency in the region assessed verbal-argumentatively.
Consumption of non-renewable resources	R	Abstraction of resources; Tendency in the region assessed verbal-argumentatively.
Change of thermal load	T	Increase or decrease of air or water temperatures; Tendency in the region assessed verbal-argumentatively.
Increase of greenhouse gas emissions	G	Increase of greenhouse gas emissions; Tendency in the region assessed verbal-argumentatively.
Energy production and consumption	E	Increase of energy consumption; decrease of share of non-renewable resources at total energy production; decrease of energy production efficiency; Tendency in the region assessed verbal-argumentatively.
Positive impacts	Po	Impacts that contribute to an improvement of the state of environment and achievement of environmental objectives in the region

* The impact factor land consumption includes all impacts, which lead to an irreversible destruction or removal of the soil such as soil sealing and soil degradation/excavation.
# The impact factor land use change defines an alteration of the utilization and/or vegetation of the area without accompanying irreversible soil loss such as afforestation on formerly used arable land.

Five selective impact factors of physical degradation, which conflict with EU policy adaptation to climate change, are investigated in detail in this research:

1. land consumption;
2. land use change;
3. fragmentation and barrier effect;
4. change of the water balance;
5. directed flooding.

The list in box 5 is neither exhaustive, nor are all impact factors always relevant in SEA-REP. The impact factors have to be operationalised, extended and modified for each individual case of SEA-REP in the EU regions. The impact factors have to be continuously and dynamically adapted with time to the respective environmental situation in a region changed with land use pressures by climate change. For instance, specific REP designations in marine or alpine zones and their impact factors were not considered. The impact factors should be specified in SEA at lower land use planning tier.

Simple cross-impact matrices were used to identify impact factors of the site-specific REP contents (table 3) and to create a link between impact factors and environmental components, here LUCCA 1-12 (table 4).

Table 3: Allocation of impact factors with relevance for LUCCA to regional plan objectives requiring site-specific SEA

Impact factor / Regional plan objectives requiring site-specific SEA	Site-specific			Site-specific/ Impact zone		
	Land consumption	Land use change	Fragmentation/Barrier effect	Change of water balance	Directed flooding	Positive environmental impact
New urban settlements	X	X	✓	X		
Industrial and commercial sites	X	X	✓	X		
Areas for the exploitation of near-surface non renewable resources	X	X	✓	X		
Tourism areas	X	X	✓	X		X
Areas for measures of technical flood control and protection	X	X	✓	X	X	X
Areas for the use of water resources		X		X		X
Areas for renewable energy production	X	X	✓			✓
Safeguarding of routes for infrastructure and social facilities	X	X	X	X		
Sites for the extension of forests		X	✓	✓		X
Electricity power supply lines	X	X	X			
X Impact can be expected in any case ✓ Case-by-case analysis is necessary						

Crosses are made on those cells where REP contents on the vertical axis are linked to an impact factor on the horizontal axis and where an impact factor is potentially affecting LUCCA. Weaknesses of these matrices are that it cannot be distinguished between direct and indirect impacts and there is also significant potential for double counting of impacts. The link between action and impact cannot always be sufficiently explained. Therefore the competent authority of the RPB will in any case need profound knowledge on the contents and consequences of the REP designations, environmental targets and state of environment in the region. Subjective decisions of links between pressures and receptors should be made transparent in scoping meetings and should be open to statements of sector environmental authorities and stakeholders.

Table 4: Allocation of impact factors to LUCCA 1-12

Impact factor / Land Uses of Importance for Adaptation to Climate Change	Site-specific			Site-specific/ Impact zone		
	Land consumption	Land use change	Fragmentation/Barrier effect	Change of water balance	Directed flooding	Positive environmental impact
LUCCA 1 – Urban areas in risk of heat stress	X			X	X	X
LUCCA 2 – Bioclimatic areas with relevance for human settlements	X	✓	X			X
LUCCA 3 – Land uses with potential for tranquil recreation in fresh air	X	X		✓	✓	X
LUCCA 4 – Urban areas in risk of flooding	X	X		X	X	X
LUCCA 5 – Land uses with potential as refugia or corridor of the ecological wildlife network	X	X	X	X	X	X
LUCCA 6 – Forested land	X	X		X	X	X
LUCCA 7 – Biotope types with potential for water capture and storage	X	X		X	X	X
LUCCA 8 – Unsealed soils	X					
LUCCA 9 – Soils for high quality agricultural food production	X	✓		X	X	
LUCCA 10 – Soils to be protected against erosion		X				X
LUCCA 11 – Freshwater resources with potential for water storage and supply	X	✓		X		X
LUCCA 12 – Land uses with potential for retention and absorption of precipitation and inundation water	X			X	X	X
X Impact can be expected in any case ✓ Case-by-case analysis is necessary						

In the following the impact factors cross-linked with LUCCA 1-12 are defined and their functions are described in more detail.

Land Consumption (Lc)

The impact factor 'land consumption' is defined as loss of land or the respective environmental component or LUCCA on the area due to soil sealing, soil extraction or soil compaction, which results in a complete loss of soil functions and of environmental media directly depending on (permeable) soil such as groundwater, surface water, fauna/flora/biodiversity, landscape, cultural and other material assets. The impact factor includes all impacts, which lead to an irreversible destruction or removal of the soil. The dimension and intensity of this impact and the connected environmental damage for human being and the environment is measured with the affected area

size and conflict class. Land consumption is one of the main unsolved ongoing environmental problems in most EU Member States (EEA 2006; Storch & Schmidt 2008) (see chap. 2.2.1). The share of settlement and transport area and degree of soil sealing is regional specific. In combination with impacts of climate change land consumption gains more importance, as soil sealing leads to loss or negative effects on LUCCA. Particularly the reduction of the efficiency of soil functions, such as the water storage capacity or the filter function through soil sealing is unsustainable and should be avoided with priority in regional planning.

Land Use Change (Lu)

The impact factor 'land use change' is defined in contrary to land consumption as an alteration of the utilisation and/or the vegetation of the area without accompanying irreversible soil (functions) loss. Examples are areas for afforestation on formerly used agricultural land: the important ecological functions of the area are not lost irreversibly, but a change of land use might lead to different positive and negative impacts on several LUCCA.

On the regional planning level it is generally not known, which parts of areas or which percentage of a specific designated area is affected by soil sealing, soil excavation and land use change. Therefore several regional designations can include land consumption and at the same time land use change. However, these two impact factors cannot overlay on an identical area (Stratmann et al. 2007b). Schmidt C. et al. (2004) do not distinguish between land consumption and land use change. Depletions of natural resources caused by deforestation are represented by the common impact factor land consumption, which categorises a general loss of the current function of the area. The distinction between land consumption and land use change has the purpose of a differentiation between a complete loss of all environmental media through soil sealing or excavation and a partial loss of the environmental media or LUCCA through a change of land use with a remaining (but changed) function of the soil.

Fragmentation and Barrier Effect (F/B)

Fragmentation is caused by man-made linear structures or intensive land uses, which cause barrier, emission or collision effects for animals, or aesthetic impairment. Linear infrastructure installations of REP are for instance secured transport routes, power supply lines or river regulations. Unfragmented areas are the remaining more or less untouched spaces between these linear structures. Landscape fragmentation, which mainly results from the expansion of transport infrastructure, is an essential area-wide environmental problem in most densely populated EU Member States (EEA 2001) leading to:

- loss of large areas of connected habitats and biotopes (unfragmented areas) and of areas for nature-close recreation or access of local populations to these areas;
- fragmentation and barriers of migrating paths of animal species creating habitat islands with genetically isolated populations;
- interruption of fresh air exchange over corridors and flow of cold air with importance for settlement areas.

These impacts are especially in the context of climate change of importance for the prevention of cumulative landscape fragmentation as a slowly proceeding process. Effects of REP objectives on the area contribute mainly together with transport development to a progressing decrease in

regional patch sizes. The Agency for Environment of Saxony (LfUG 2005a) considers specific parameter and geographic data during the measurement of fragmentation of areas as barriers with separation effect at state land use planning level:

- federal, district and local roads and motorways;
- railway lines;
- rivers from a width of six meters upwards;
- settlement areas;
- silent water bodies/stagnant water.

Fragmentation in SEA-REP can additionally to the number and size of unfragmented areas be measured in sections (cutting length) in kilometre [km] and rest area shares in percent [%]. RP Gießen (2006) distinguished between linear elements:

1. cutting an area at the edge with the rest shares < 10 % overlap or
2. cutting it with > 10 % overlap.

The cutting length and rest shares can assist in the comparison of alternatives. Additional verbal-argumentative case-by-case assessments are necessary to compare barrier effects.

Change of the Water Balance (Cw)

'Change of the water balance' (Cw) can mean on the one hand a decrease of the availability of freshwater quantity in a region, caused by water abstraction or reduction of the groundwater development rate (e.g. also through soil sealing); and on the other, an increase of water availability caused by surface and groundwater enrichment through a purposed lifting of the groundwater level. The water balance in a region depends on input and output of water by regional developments. Land use changes influence the capacity of the soil and vegetation for precipitation water retention, storage and supply. Climate change potentially increases the vulnerability to evaporation and transpiration. The terrestrial water balance can be assessed with the groundwater development rate (Voigt et al. 2004), which will be influenced by effects of climate change to different extents in the EU regions. Relevant factors are temporary high aridity of the air and bare soil, decreased precipitation quantity and frequency, increased evaporation and transpiration, decreased leakage water quantities.

A change of the groundwater level is generally connected to changes in water regimes of groundwater and water bodies, land consumption or land use change. Relevant REP designations are especially planned sites for open-cast mining activities and drinking water catchments areas, which usually lead to groundwater abstraction on a large area. Groundwater level decrease leads to impacts on wetlands and moors, which play an important role for carbon capture.

The impact factor change of the water balance is measured on the affected site and impact zone in square kilometres [km²] or hectares [ha]. The impact zone has to be estimated for the entire catchment area of the affected groundwater regime within the spatial scope of the regional plan and affected transborder areas.

Directed flooding (Fl)

Directed flooding is defined as man-made targeted increase of groundwater level above the ground

on a specific area with the main purpose to protect human beings from natural floods. Directed flooding of areas is often a consequence of flood protection measures or designation of certain land uses in areas, which are endangered by floods. With a similar impact, recultivation measures on formerly used mining areas can have the objective of a flooded lignite pit with different functions for nature conservation, recreation or other uses.

A directed flooding effect can be measured on the individually affected site and impact zone in square kilometres [km²] or hectares [ha].

Positive Impacts (Po)

Examples of positive effects of regional plan objectives, which are part of the comparison of site-specific alternative sites, are effects of afforestation areas on ecosystems, ecological wildlife networks or soil erosion or of flood prevention measures on human health, agricultural use or ecosystems through the restoration of floodplains by moving ditches further away from the river bed. Such restorations require EIA and have mainly positive impacts on the river ecosystem (beside likely negative impacts in form of loss of arable or grassland for the agricultural sector).

Potential positive impacts to be considered in the overall assessment of the regional plan and during the comparison of alternatives in SEA-REP are generally those that oppose negative impacts. Only actions and measures that indicate a change are considered as positive effects in site-specific assessment and comparison of alternative sites; not measures that only safeguard the current state of the environment. Positive impacts are not mitigations, but they occur, if certain land designations are cancelled, for instance settlement areas, which had been designated in the previous REP version. Afforestation sites, drinking water catchment areas and sites for technical flood prevention have site-specific positive effects on LUCCA.

Positive impacts were considered during the comparison of alternatives in a second step after significant negative effects were identified, described and assessed. A misuse of positive impacts by the RPB, in order to achieve a better result in the alternative comparison, must be prevented. For instance the later integration of Special Areas for Conservation (SAC) under the EC Habitats Directive, which are legally obligatorily to be designated, could become subject of the assessment of positive effects. Positive impacts on the environment cannot balance negative effects. A specific area size for nature and landscape cannot be designated to balance the same area size of an industrial development in the SEA (Schmidt C. 2002: 46). In the same way the later remediation of mining areas cannot be considered as positive impact, because first of all this development leads to a complete loss of the environmental components on the affected site.

3.4.4 Impact Zones

The spatial scope of the impact factors ‘change of the water balance’ and ‘directed flooding’ covers effects on the land use and natural resources on the affected area and on the impact zone within the regional borders and on transborder areas (Stratmann et al. 2007b; Eberle & Jacoby 2003; Jacoby 2000, 2001). It can be distinguished between different spatial scopes of environmental impacts with relevance for the specific affected site (PVB 2006; RP Gießen 2006; Reinke et al. 2005a, 2005b; Recktenwald 1994: 118):

- impacts on the affected area as interference of the affected planning area and state of environment of LUCCA. These impacts are characterised by a direct concern (in the sense of loss) of the qualities and functions of LUCCA.
- impacts on the impact zone as interference of the impact zone of the designation and state of environment of LUCCA. They define an indirect concern of the quality and function of LUCCA for instance through water abstraction or flooding.

Impact zones are pragmatically defined from a minimum of a 300 m distance, which is practicable for the regional scale of 1: 200 000 (Stock 2005). These impact zones determine the spatial search area to be considered in SEA-REP as geographical dimension of the likely environmental effect on the water regime. In SEA-REP impact zones are necessary to make sure that the potential spatial scope of an impact on the environment is adequately considered. An impact zone goes beyond the spatial scope of a directly by impacts of REP designations affected area. The abstraction or inflow of freshwater can have large-scale effects, which are determined by the natural flow and catchment of the water body or groundwater aquifer (Koning 1987: 50). As the spatial impact of water abstraction at regional plan level can generally only be estimated qualitatively, its distance to sensitive land uses is relevant for a quantitative assessment. An accurate bordering of the effect areas of changes of the water balance and statements on their long range effect cannot be made on the scale of regional land use planning (Recktenwald 1994: 129). Therefore estimated assumptions have to be modified for individual cases for the impact factors of change of water regime and pollution differently, and more detailed recommendations have to be formulated for lower tiers. For an assessment of groundwater pollution a vulnerability map can be used, which designates water catchment areas and groundwater protection zones with respective statements on their protection status and management options (UBA 2002: 19; Hannapel & Voigt 1999).

The environmental state of the affected site and impact zone is cross-linked with the impact factors acting on the individual sites (see figure 16).

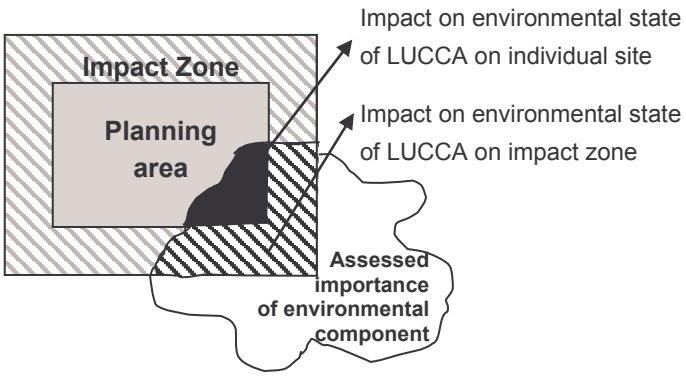

Figure 16: Interaction of impacts caused by site-specific regional planning designations with the environmental state of LUCCA on the affected site

In transSEA quantitative thresholds for the definition of impact zones were found in and transferred from minimum distance regulations, such as the minimum distance ordinance of North-Rhine-Westphalia (MUNLV NRW 1998; SMWA 2005; TA Lärm) or for EIA for wind power plants (e.g. MBV/MUNLV NRW 2005), which were applied and approved in practice. Additionally guidance

values from regional planning, sector planning and SEA case studies were derived (Kaule 2002, RPV OL-NS REP Begründungsteil; PGW 2002; PVB 2005, 2006; Schmidt C. 2002: 43, 44; Stratmann et al. 2007a). The buffer zones listed in the distance regulation of NRW are only valid for distances between industrial/commercial areas and housing areas in the frame of the binding land use planning and therefore only for permanent or long-lasting types of uses. The ordinance proposes minimum distances for spatially-relevant developments that have likely significant impacts, such as dust, odour, pollution, radiation and noise, and are to be assessed after Art. 50 BImSchG. Impact zones for the impact factors 'change of the water regime' and 'directed flooding' have to be estimated on the basis of the water catchment areas in a region. A table for proposed minimum distances for all impact factors with a spatial scope of impact zones (see box 5) can be found in the Annex of this thesis (table A2 Annex).

3.5 Overall Strategic Assessment of the Regional Plan

Beside an assessment of impacts on specific sites, in a second phase of SEA-REP, an assessment of conceptual, not site-specific plan contents, in an overall plan assessment is required (ARL 2001, 2002). The need to predict and assess impacts of REP separately from other relevant considerations in plan-making, and to look at the impacts not just individually, but also comprehensively, is new for German regional planning with SEA (Bunge 2005a: 114). The aim is an evaluation of designation criteria, a comparison of REP objectives with the status quo prognosis, and a balance of negative and positive impacts with the implementation of the plan in the entire region (Stratmann et al. 2007b).

Objectives of regional planning with potential positive impacts on LUCCA to be considered in the overall plan assessment are objectives for the safeguarding of sensitive land uses against conflicting REP objectives and objectives for the protection or maintenance of areas of high value or sensitivity. Beside consideration of impacts of REP contents, integrated designations from other sector plans are considered in the assessment of cumulative impacts (ARL 2001: 7). These are not part of the SEA-REP under the responsibility of the RPB, but can be of importance as initial impacts, which add to or overlap with the REP impacts. Especially SEA-REP, which integrates all designations from sector planning, such as agricultural sector, mining sector, transport sector, industrial sector, housing sector, helps to identify early warning of large scale effects of all regional land uses. Integrated sector plan contents, which were not assessed site-specifically, potentially cause cumulative impacts with impacts of REP contents and effects of climate change. Furthermore, part of the overall assessment can be qualitative criteria for decisions on plan designations, such as the consideration of centres and axis, urban densities, link to existent infrastructure, land use categories, development focuses, recreational uses, and other REP principles (ARL 2001, 2002).

The overall assessment can mainly be carried out for individual types of impact factors (e.g. total length of fragmenting lines in the region in kilometre), for each environmental media separately (e.g. impacts on soil; impacts on fauna and flora) or for certain areas, where several impacts co-occur and overlay. The assessment of cumulative impacts should take place for regional specific ecological space units, which include areas, which are likely to be significantly affected, and areas, which are characterised by a special environmental relevance (ARL 2001: 7). The overlap of

individual environmental conflicts, e.g. land consumptions, in specific spatial areas makes conflicts transparent and facilitates the political discussion of mitigations. In the case the scope of an entire region is too large and municipalities too small in size for an overall assessment, a respective region may be split into rural districts, or according to certain conditions of the natural units. Summary indicators for degradation can be used to assess the overall plan, e.g. total land consumption and fragmentation level or total impacts on the quantitative water resources in a region. Another possible option are indicators referring to specific spatial units (e.g. the average area size of unfragmented areas in the region, the percentage of broad-leaved forest cover at total territory, the share of recreational areas in proximity of agglomeration areas affected by land use change).

Results of the overall assessment of the entire regional plan are statements, which indicate the future development of the regional land use and resources with the help of LUCCA. For instance the trend of soil sealing may be expressed in such as 'getting better or worse' or a simple scale from + (positive) to – (negative). It further is useful to link predictions to specific environmental regional orientation objectives, e.g. does the REP or its designation integrate climate change effects and promote change in a desired direction towards meeting adaptation targets? Which areas of LUCCA are prone to degradation and thus create a conflict with adaptation to climate change? How will the region develop until 2020? Figure 17 presents an example for a balance of changes of regional land uses of importance for adaptation to climate change. The overall assessment shall lead to a statement, if the environmental tendency in the region will be positive or negative with the implementation of the regional plan. Therefore environmental remediation or release of pressure on the environment, such as the withdrawal of plan objectives of the former regional plan version (e.g. settlement areas) or the designation of open spaces, recreational areas etc., shall be considered. The balancing of the overall environmental situation in the regional planning area thus also considers REP contents with only positive environmental impacts (MKRO 2004: 6f).

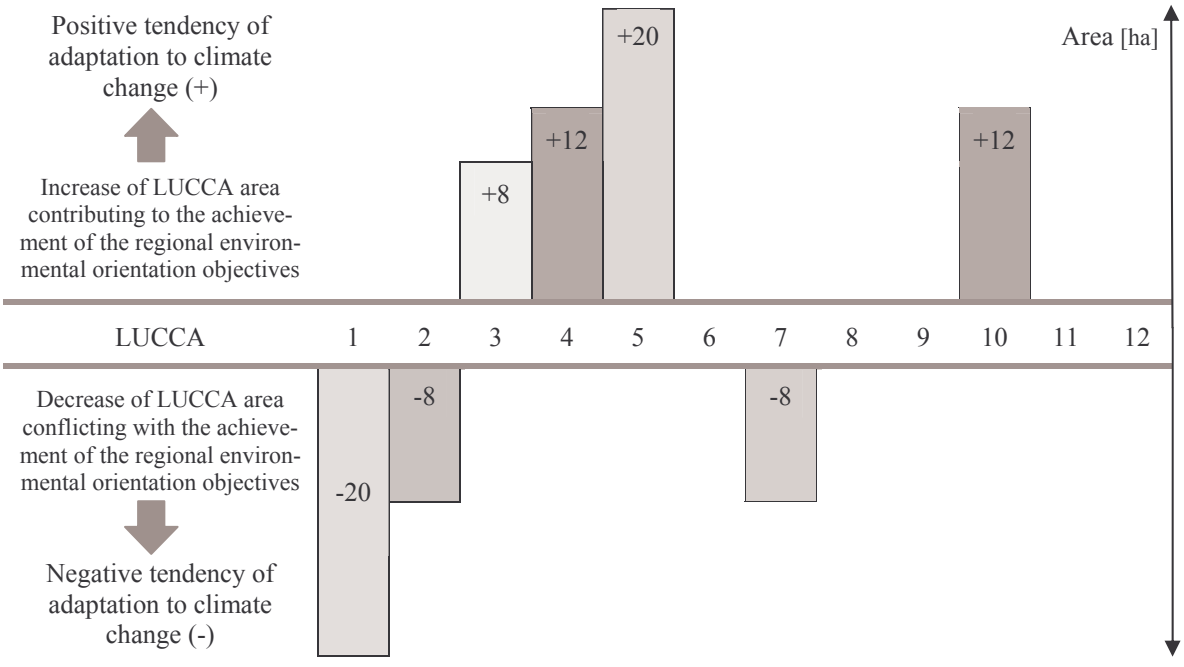

Figure 17: Potential balance for the loss of land uses with importance for climate change (LUCCA) in a region (example)

3.5.1 Assessing Cumulative Impacts

Special attention requires the assessment of (transboundary) cumulative and synergistic effects, including future effects of global climate change. Cumulative effects are defined by Gilpin (1995: 31) as "*effects which combine from different projects and which persist to the long-term detriment of the environment.*" They indicate a negative tendency of degradation or positive tendency of remediation in a region, and show the level of optimisation of the regional plan and whether adequate mitigation and adaptation measures are put in place. In the overall assessment of an entire regional plan all REP contents as a common designation shall be assessed on the basis of the status-quo-prognosis, i. e. a development of the environmental state on the basis of environmental impacts in the region without an amendment of the regional plan (MKRO 2004: 6). Beside adverse effects, particularly positive and cumulative effects shall be considered in the overall strategic assessment of the plan (Annex I lit. f of the SEA Directive).

The overlap of impact factors on the same area cause cumulative or synergic impacts. These impacts have not been considered well enough in environmental assessments in the past, due to methodological constraints and knowledge (Dixon & Montz 1995; Van Straaten 1996). Impact factors are linked to REP contents or other past, present or reasonably foreseeable future activities or changes of conditions in the region, which may occur over time and space (IUCN 1996). Consequently cumulative impacts often occur in areas, where a high density and/or high frequency of human activity overlap (Burris & Canter 1997). Additive negative effects of climate change on specific sites in the EU regions cannot be predicted in detail, but they have to be considered with precaution and they underline the urgent need for adequate sustainable land management. In transSEA a method and process for the assessment of cumulative impacts in SEA-REP was proposed (Stratmann et al. 2007a).

3.5.2 Assessing Designation Criteria of Regional Planning

In regional planning specific designation criteria and methods of designations are traditionally used, in order to satisfy the demand for land under the objectives of sustainable development (see box 6). A regional plan designation is defined as a standardised provision in a regional land use plan, which provides notice to other authorities and the public of an intention by the regional planning body to use land in the future for a particular activity or reason (e.g. priority area for agriculture, priority area for nature conservation and landscape maintenance). Once a site is designated for a particular purpose and was subject to the weighting process, it becomes binding for the lower preparatory and binding land use plans.

Designation criteria should be at least considered in the overall assessment of SEA-REP (ARL 2001). A possibility is to integrate these criteria into the indicator system and thus site-specific assessment and comparison of site alternatives, e.g. minimum distances, the connection of urban areas to existent transport infrastructure or the extension of existent forested areas (RP Gießen 2006; RPV Mittlerer Oberrhein 2005, 2006). The designation of housing sites is based on population forecasts, a region-specific calculation of quantitative demand for dwellings and densities of settlements. Another example is the widely approved method, used for the designation of sites for wind energy generation in Germany, covering a special process and evaluation of suitability areas. This traditionally considers the exclusion of taboo zones and areas of landscape

aesthetics of high importance, as well as minimum distances to neighbouring sensitive land uses.

In the overall assessment of the regional plan strategic options, designation criteria and structural alternatives (Schmidt et al. 2004; Jacoby 2000) should be assessed on the basis of criteria such as minimum area sizes, minimum distances, existent infrastructure, concentration or restriction of certain types of regional plan designations in different natural areas. A spatial concentration of development, for instance, may promote a reduction of energy use and waste.

Box 6: Designation criteria of sustainable regional planning to be considered in SEA-REP

(Sources: SMUR 1997: 5-7; RPV OL-NS 2000; PGW 2002).

1. Taboo zones:

⇨ Designation of strict protected land uses as priority areas for nature and landscape, soil, water, air.

2. Minimum distances:

⇨ Determination of buffer zones between origin of harmful effects and sensitive land uses.

3. Protection of unsealed soils against land consumption:

⇨ Avoidance and reduction of land consumption caused through consideration of restriction of out-of-town urban and retail development, reuse of brown fields;

⇨ Consideration of population forecast and demographic change;

⇨ Principle of decentralisation, central places;

⇨ Avoidance of an overstrain of urban axes;

⇨ Designation of agricultural soils of high productivity as priority area for agriculture.

4. Designation criteria for urban development:

⇨ a good accessibility of existent infrastructure, facilities and employment due to their location and connection to transport systems (passive accessibility);

⇨ a high accessibility potential due to their location, i.e. facilities and employment are well accessible (active accessibility);

⇨concentrate settlement growth on the network of spatial central places and on development axes.

5. Protection of open areas and floodplains:

⇨ Prevent from industrial development on green fields in urban areas in high risk of heat stress;

⇨ Preserve and improve open spaces in proximity of agglomeration areas, and decentralised settlements;

⇨ Prohibit construction on floodplains in unspoiled riverside landscapes.

6. Safeguarding of existent forests:

⇨ Designation criteria for the protection of priority and reserve area for the existent woodland: e.g. rest wooded areas in forest-poor regions; forests with regionally important protection functions (flood protection, climate protection, preservation of genetic variety);

7. Link urban developments to existent transport and energy infrastructure:

⇨ Consideration of distance to travel from housing sites to urban centres and their interdependencies with public transport systems, traffic flows, traffic volumes and number of commuters;

⇨ Consideration of distance from commercial sites to the next motorway connection;

⇨ Length of necessary power supply lines from e.g. wind turbines to connection point.

8. Analyse need for state land use objectives:

⇨ Check possibility of designations to less than 100 % of the requirements from state land use plan;

⇨ Link location and dimension of designations to regional-specific environmental quality objectives.

It should be part of SEA-REP to check, if certain principles of regional planning, such as minimum distances between designations causing adverse impacts and neighbouring sensitive land uses are in place. Part of the assessment can also be an analysis of the carbon mitigation potential.

4. SEA-REP Indicator System

In the baseline-led SEA-REP components of the baseline data were described through state of environment indicators. The SEA-REP indicator system is strongly related to environmental political objective setting (SRU 1998: 8). This German approach of a SEA-REP indicator system was developed from environmental media, environmental objectives and regionally assessed environmental information from the region OL-NS in Saxony (figure 18). An environmental conflict analysis was applied for the site-specific assessment (see chap. 3.4).

Environmental indicators are parameter, which serve to describe a specific environmental situation, the 'indicandum' or a complex system, and to measure not directly measurable circumstances. Müller and Wiggering (2004: 10, 5) defined indicators as state variables, which represent complex interrelations in measurable values. Fürst et al. (1992: 30) stressed that the validity of the conclusion of an indicator depends on its relations with its indicandum, which means to which extent the substitutional function is theoretically secured. Box 7 delivers a more specific definition of indicators for SEA-REP.

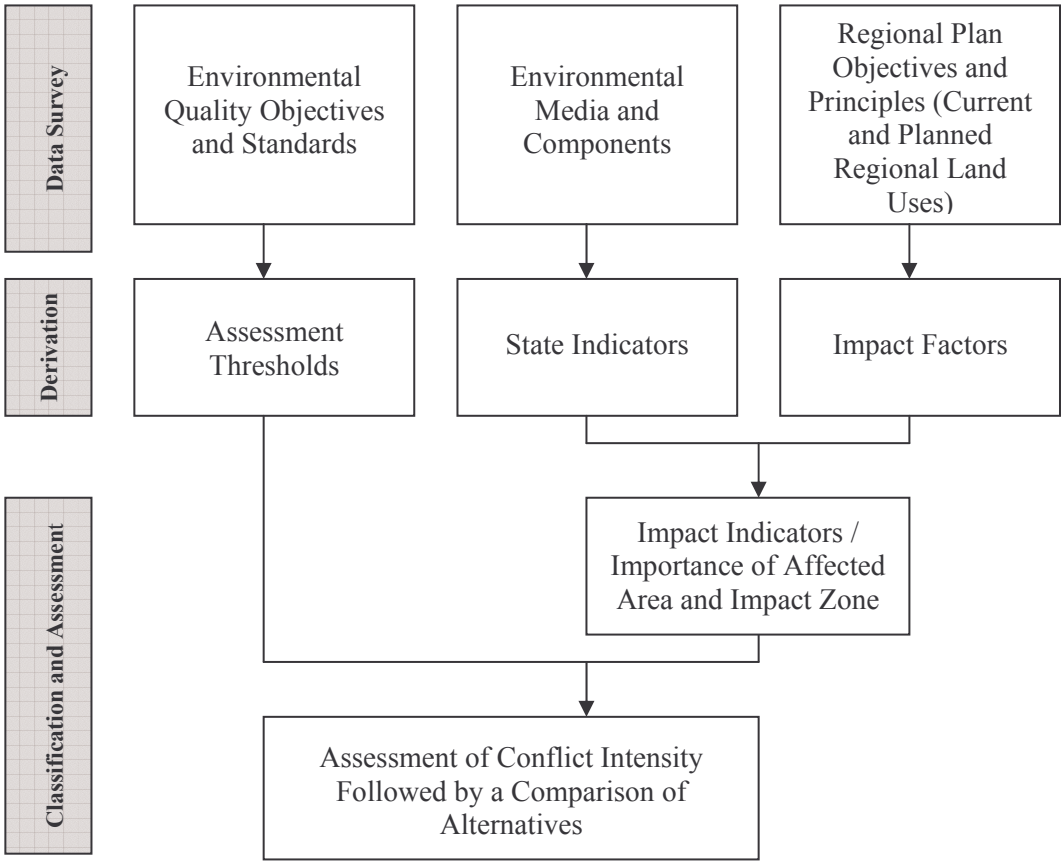

Figure 18: Assessment methodology of environmental conflict analysis in SEA-REP

(Sources: after Hamhaber et al. 1992: 72; Stratmann et al. 2007a)

Box 7: Definition of indicators for SEA-REP

(Source: modified from Thérivel 2004)

Indicators create and present the link between strategic regional planning objectives and how they are implemented in the region with specific impacts (identified as impact factors) on the affected state of environment in the region (identified as environmental components and land uses for the adaptation to climate change – LUCCA). Indicators are needed to test, whether the strategic planning objectives have conflicts with environmental objectives, particularly objectives for the adaptation to climate change, and whether these are achieved (during the process of monitoring).

They can be used during the monitoring of the REP implementation, in order to examine, whether the objectives are being achieved, and to identify the REP level of compliance with environmental targets. They assist in making the change of a region's environmental status transparent for the public.

4.1 Environmental Media and Environmental Components

A major task during the site-specific assessment of SEA-REP is to identify indicators, which measure all significant impacts of the regional plan on the abiotic and biotic environmental media human (human health and population), biodiversity (flora, fauna, habitats, species, genetics) soil, water (groundwater, water bodies), climate and air, landscapes and cultural and other material assets – with special attention to geographic specifications of the relevant region – as well as their interrelations. These fundamental environmental media to be considered in SEA-REP are determined in the EC EIA Directive, commonly accepted and accredited in the national EIA Acts or environmental codes of the EU Member States, and extended with Annex I lit. f of the EC SEA Directive. The environmental media characterise important abiotic, biotic and aesthetic characteristics of a space, as well as existent initial impacts and land uses. The SEA Directive puts an emphasis on the cross-cutting issues human health and biodiversity, but does not specifically integrate standards for adaptation to climate change.

The environmental media were the basis for a determination of more detailed environmental components for SEA-REP, such as biotope types and habitats of the region, protected nature conservation sites, agricultural production capacity of the soil, or the groundwater development rate (table 5; Stratmann et al. 2007a; Schmidt & Helbron 2008). The aim is to make qualities of interest of the society, which are characteristics or parameters of the environmental media, measurable. The presented environmental components are thus a result of a more or less subjective selection in the course of the project transSEA, which can be generally be questioned (Köppel et al. 2004: 213). A further specification for each EU region's state of environment and at lower planning tiers is crucial.

Checklists for each environmental component were developed, which created the fundament for the determination of state indicators, impact indicators, assessment thresholds and conflict classes. These systematically document definitions, environmental objectives, environmental data needs, the derivation of assessment thresholds from assessments of the state of environment, and issues of tiering and mitigation.

Table 5: Environmental components and state indicators for SEA-REP

(Source: modified from Helbron & Schmidt M. 2007)

Code	Environmental component	State indicator
Environmental media human health		
HH 1	Noise pollution in settlement areas	Land uses of settlement areas to be protected against noise with priority
HH 2	Pollution in settlement areas	Land uses of settlement areas to be protected against pollution with priority
Environmental media fauna, flora, biodiversity		
FFB 1	Biotope types and habitats	Five assessment classes of the biotope and land use types after Bastian (1994), protection states of biotopes after Saxon Nature Conservation Act (SächsNatSchG)
FFB 2	Protected species	Importance of the areas for protected species after Annex II or IV Habitats Directive, Annex I Wild Birds Directive, red list of Germany or red list of Saxony
FFB 3	Biotope connection network	Biotope connection areas and elements with transborder, Saxon or regional importance
FFB 4	Protected areas	Importance of national parks, nature reserves and biosphere reserves in zones
FFB 5	SAC areas and SPA	Importance of areas protected after Habitats Directive and SPA
Environmental media soil		
So 1	Natural productivity	Five productivity classes (F classes) of the soil concept map
So 2	Storage and regulation function	Five buffer classes (P classes) of the soil concept map
So 3	Biotic habitat function	Site class V of the soil concept map (special sites, which are moist, dry or poor in nutrients)
So 4	Erosion risk	Erosion risk through water and wind in five classes, erosion protection forest
So 5	Contaminated soils	Urgency of need for action on contaminated sites in five classes
So 6	Unsealed area	Largely unsealed areas (< 25 %) or rest areas, which are not within the sealing classes of (26-50 %, 51-75 %, 76-100 %); brownfield sites according to data of lower planning levels, aerial data and field trips
Environmental media groundwater		
Gw 1	Groundwater development rate	Groundwater development rate in three classes in mm/a in groundwater catchment area
Gw 2	Protection of Groundwater against pollution	Protection potential of groundwater cover in three classes
Gw 3	Groundwater level below ground	Average groundwater level below ground < 2 m, in connection with biotopes depending on groundwater and average groundwater level >= 2 m in connection with woodland and forest biotopes depending on groundwater after CIR and selective biotope map

Code	Environmental component	State indicator
Gw 4	Drinking water catchment areas	Importance of drinking water catchment area in protection zones
Environmental media water bodies		
Wa 1	Biological structure of rivers and streams	Biological structure in seven classes
Wa 2	Floodplains and retention areas	Floodplains and retention areas; nature-close river sections with biological structure 1-2 or protection after Art. 26 SächsNatSchG
Wa 3	Water quality of rivers and streams	Water quality in seven classes
Wa 4	Barrierless flow of rivers and streams	Importance of rivers and streams concerning their barrierless flow in categories I and II
Environmental media air and climate		
AC 1	Bioclimatic condition	Need for preservation of open areas from climatic perspective in three classes; forests > 4 ha for fresh air production; climate protection forest
AC 2	Highly polluted areas	Potential highly polluted areas in valleys and settlement areas in dependence on traffic volume and industry/commerce; immission protection forest
Environmental media landscape		
La 1	Landscape character	Landscape character quality assessed in three classes
La 2	Areas for recreation in proximity of central places	Suitability of areas > 4 ha for recreation in proximity of settlement areas of central places
La 3	Unfragmented areas	Importance of unfragmented areas related to their size in three classes
La 4	Protected areas for recreation and open areas in need for protection against noise	Importance of biosphere reserves, landscape protection areas, nature parks, recreation forests
Environmental media cultural and other material assets		
Cu 1	Constructed cultural and material assets, monuments	Protected cultural heritage and regionally important cultural monuments and other constructions
Cu 2	Landscapes, elements, soils with archive function	Natural monuments, protected landscapes and elements, archaeological soils and geotopes

4.2 Land Uses for Adaptation to Climate Change (LUCCA)

The purpose of a separate and transparent proposal of land uses for the adaptation to climate change (LUCCA) was to add a module of guidance indicators to the general assessment of all significant impacts affecting all environmental media in SEA-REP (see figure 19).

The LUCCA module does not replace a wide and comprehensive assessment approach led by the environmental baseline (e.g. PVB 2006; Stratmann et al. 2007a), but has the aim of putting an

emphasis on the key problem field of physical degradation and its conflict with adaptation of regional land use to effects of climate change. These effects are potentially increased in their significance with pressures of the regional plan designations in form of ongoing land consumption, land use change, fragmentation/barrier function, change of water balance or directed flooding.

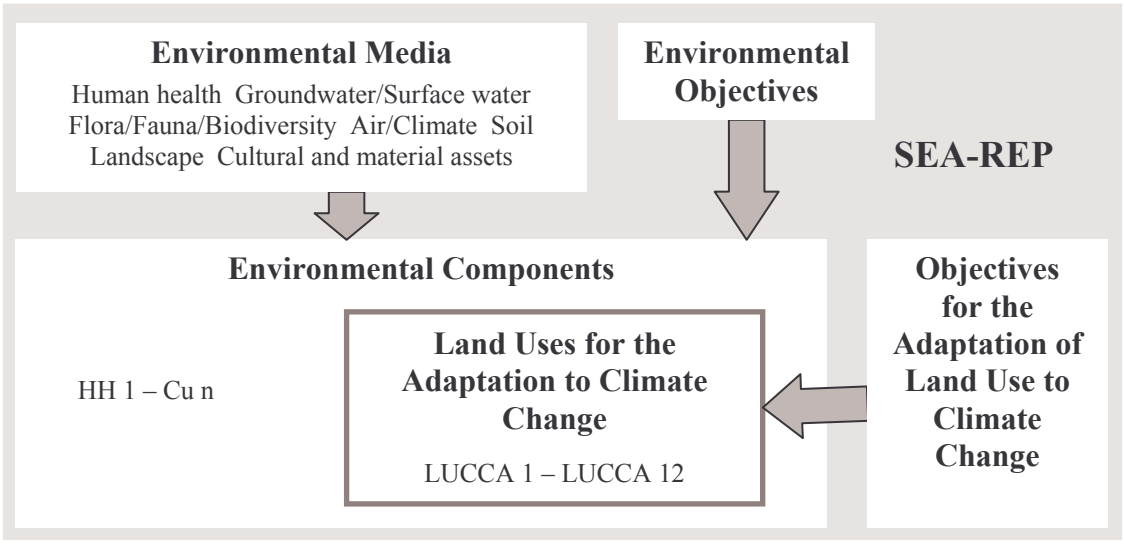

Figure 19: Integration of land uses for the adaptation to climate change (LUCCA) into SEA-REP

(HH 1 stands for the first state indicator for human health, Cu n for the last state indicator for cultural/material assets)

At this early phase of climate change integration into spatial planning systems in the EU, a separate tool shall be created, which makes the efforts of regional planning to integrate measures for the adaptation to climate change transparent, and allows an evaluation of a region's adaptation process. Climate change issues shall not be tackled as separate "*climatic risk factors*" (CCW et al. 2004b), but shall be methodologically linked to the analysis of all REP impacts and receptors of adverse effects. Selected environmental components of importance in the context of adaptation of land use to climate change were selected and partly summarised to LUCCA. These were explicitly linked to the regional environmental orientation objectives formulated in chapter 2.4. LUCCA represent values, importance, level of vulnerability or resilience and initial impacts of nature and landscape, and are an important basis for the environmental assessment of REP impacts on the current environmental state of the region, including initial pollution and likely adverse effects of climate change (figure 20).

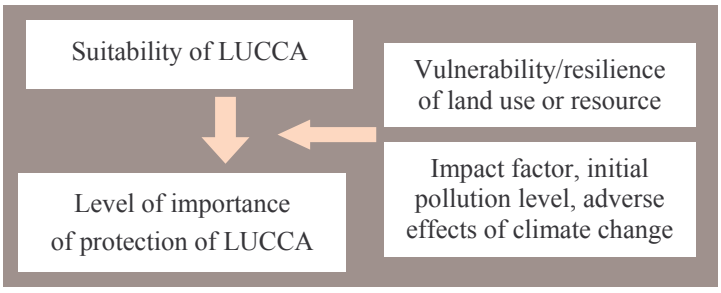

Figure 20: Factors determining the importance of LUCCA

Adaptation of land uses requires predictions of future potentials and constraints of land uses, at least within the time scale of regional planning of 15 to 20 years. The spatial scale varies due to political, administrative and geographic borders. In the context of adaptation to climate change regional environmental potentials inform on the ability of a space to produce specific performances within the landscape regime, with regard to one or several environmental factors, their vulnerability and resilience. They address the ability to take over specific functions for adaptation of land and resources to climate change from an anthropocentric point of view. The term 'potential' includes improvement and depletion of functions and performance of the environment as a living space for plants and animals and as existence basis for human being. A potential implies that the possibility of a use of LUCCA exists; whether it is really used depends on the local conditions. The presentation of future land use potentials for adaptation to climate change simplifies a complex and interdependent reality. The values of the potentials are influenced by the assessment of the state of the LUCCA indicators. The better the availability of high quality data, the smaller is the implementation time of this baseline-led assessment approach for LUCCA. The necessary actuality of baseline data depends on the state of the environmental media and their development dynamic. In the EU countries with a current lack of a comprehensive national or regional data system, the data compilation and application will require more effort, than in countries with well developed area-wide environmental information systems.

The land uses for adaptation to climate change (LUCCA 1-12) were categorised and structured according to their importance for the protection of i) human health and air, ii) the structure and function of ecosystems, and iii) the natural resources soil and water (UBA 1995). They integrate international, national and federal policy for adaptation of land use to climate change into the SEA-REP indicator system. They represent land uses of high importance and potential for adaptation (see box 8).

Box 8: Environmental components of land uses for the adaptation to climate change (LUCCA)
Land Uses of Importance for the Protection of Human Health and Air LUCCA 1 – Urban areas in risk of heat stress LUCCA 2 – Bio-climatic areas with relevance for urban settlements LUCCA 3 – Land uses with potential for tranquil recreation in fresh air LUCCA 4 – Urban areas in risk of flooding
Land Uses of Importance for the Protection of the Structure and Function of Ecosystems LUCCA 5 – Areas with potential as refugia or corridor of the ecological wildlife network LUCCA 6 – Forested land LUCCA 7 – Biotope types with potential for water capture and storage
Land Uses of Importance for the Protection of the Natural Resources Soil and Water LUCCA 8 – Unsealed soils LUCCA 9 – Soils for high quality agricultural food production LUCCA 10 – Soils to be protected against erosion LUCCA 11 – Freshwater resources with potential for water storage and supply LUCCA 12 – Land uses with potential for retention and absorption of precipitation and inundation water

Some of the applied environmental components are already efficiently implemented in German regional planning: these are for instance protected nature conservation areas and recreational sites, integrated from landscape planning, sites for technical flood protection or improved flood risk management (improvement of dikes, dams, flood gates etc.) (see chap. 3.5.1). These are designated as priority and reserve areas and serve the protection of land and resources, the mitigation of negative impacts of regional developments, and can be at the same time valuable for the adaptation to effects of climate change. As the severity of effects of climate change will depend on different types of adaptation measures, including new practices to respond to or anticipate climate change, regional planning should make any adaptation effort even under high uncertainty of future changes of the environment. Sustainable land use must for instance consequently include measures for the prevention of inappropriate new urban settlements or other constructed sites in the floodplains of Europe's main rivers and streams (CCW et al. 2004b: 2). Planners could even suggest an abandonment of frequently and heavily flooded urbanised areas in the future.

LUCCA shall protect the environment and human health from cumulative impacts of effects of climate change and REP impacts in a preventive way. The aim is to mitigate endangering and not justifiable risks through anthropogenic impacts with a promotion of remediation towards an increase of the adaptive capacity or regional land uses. Conflicts with adaptation to climate change shall be made transparent for the public. The time measure of man-made impacts and interventions on the environment should be put in a balanced relation to the time measure of the reaction capacity of the environmentally relevant bio-geographic processes (Müller & Wiggering 2004: 8). Environmental indicators make the examination of the implementation of environmental objectives on the basis of inter-subjective analysis of the situation possible. Adaptation to climate change and the variability of the environment face the inherent challenge that climate is driven by complex large scale processes. Adaptation measures have to be implemented at regional and local level to tackle impacts on livelihoods. Without participation of regional planning authorities from the very beginning of the integration of climate change issues into decision-making, technical and administrative response and adaptation measures will fail. The efficiency of adaptation measures will depend on their practical implementation and adequate mitigation of conflicts of adverse effects and natural hazards at a highest spatially-relevant planning scale. The slow process of the acceptance of societies of preventive measures as response to environmental conflicts, mainly due to great uncertainties of cost-benefit relations, shall be accelerated with the help of LUCCA.

4.3 Environmental State and Impact Indicators

4.3.1 Environmental State Indicators

Environmental state indicators for SEA-REP shall adequately describe the environmental media, spatially inclusive and comprehensive at regional planning level. They provide the current state of environment, including initial negative impacts on the potentially affected areas and search sites (impact zones). Interrelationships between all environmental media shall be made transparent. The validity of the indicators has to be verified through the distribution of environmental data assessed, or classified by specialists of the respective sectoral departments.

Environmental state indicators are used to analyse, whether the REP contents comply with

environmental objectives and standards and promote a sustainable development of the region. They represent all environmental components and LUCCA. They have the function to present the protection values and sensitivities, as well as impacts on nature and landscape and are an important basic information for SEA-REP. Quantitative environmental state indicators describe the state of the environment, whilst considering initial pollution and development potentials at the same time. The indicators for the description of the environmental quality shall on the one hand make a statement on the quality of affected environmental media, and on the other deliver measuring values for possible measures (feedback) (see Weigl & Hagauer 2004).

The ‘right number’ of state indicators in SEA-REP for the adaptation of regional land use to climate change (LUCCA) depends on many factors including what type of scope and regional audience the environmental report will have, how much time is available to research the data, the number of issues involved, and any specific needs of the regional community. A final regionally-specific modified set of indicators should cover all the issues that are important in a specific region (e.g. additional environmental components on coastal and marine ecosystem protection for coastal regions). The proposed LUCCA represent a first German standard of a measurement instrument that can be a model for SEA-REP in other EU regions and allows comparison of conflict classes between different assessments, in spite of a previous operationalisation of the assessment variables/parameters in a respective region. In the future further research, targets and conflict maps for adaptation of land use to climate change are deemed to be valuable.

4.3.2 Impact Indicators

From all impact factors (see box 6) so called impact indicators were derived as a cross-link to the affected environmental component and land uses for adaptation to climate change. Impact indicators describe in relation to space and site the impacts of regional plan designations on the respective environmental component. With their interference with the state of environment on the affected area, the environmentally-relevant importance of the impacts is assessed with the help of conflict classes. Whilst impact factors lead to physical-material quantitative and qualitative changes of nature and landscape on the affected area and impact zone in a region, the impact indicators are necessary to measure and assess these impacts. An impact factor is the descriptive part of the impacts – the impact indicator is the tool to measure this descriptive part (Reinke et al. 2005b). Five standardised impact indicators, assessing site-specific physical impacts on LUCCA, are:

- land consumption of land uses for the adaptation to climate change (LUCCA) of superior, general or inferior importance on the affected site in hectares;
- land use change of land uses for the adaptation to climate change (LUCCA) of superior, general or inferior importance on the affected site in hectares;
- fragmentation/barrier effect affecting land uses for the adaptation to climate change (LUCCA) of superior, general or inferior importance in km of cutting length and/or rest area share and/or ratio of separated areas in % on the affected site in hectares;
- change of the water balance affecting land uses for the adaptation to climate change (LUCCA) of superior, general or inferior importance on the affected site and impact zone in hectares;
- directed flooding affecting land uses for the adaptation to climate change (LUCCA) of superior, general or inferior importance on the affected site and impact zone in hectares.

4.3.3 Criteria for Indicator Selection

The step of indicator selection is crucial in SEA, as poorly chosen indicators may lead to "*a biased or limited SEA process*" (Thérivel 2004: 76). In the course of the selection of adequate environmental indicators for SEA-REP, international, EU, national and regional environmental and sustainability indicator catalogues were analysed (e.g. OECD 1998; EEA 2004; UBA 2000; BMU 1997, 2000; StBA 1998; LfUG 1999a, 2001b, 2003a, 2003b; Hennig 2001). Additionally expertise on the application of indicators in landscape planning, sector planning and spatial planning was consulted (e.g. Meyer-Aurich et al. 2000; EEA 2000; Borken & Gühnemann 2004). A task was to strive for a 'manageable' and straightforward system of assessment criteria, which is usable in a formal decision-making process and can be reproduced for later amendments of REP. Therefore the following criteria for the selection of state indicators were applied in the order of priority:

1. quantifiable, measurable and reproducible;
2. environmental media and environmental objective-orientated;
3. compatible with existent international and national indicator systems;
4. scientifically robust and credible;
5. capable of being monitored to show regional trends over time;
6. user-friendly and justifiable in effort and costs.

The development of a SEA-REP indicator system is an on-going activity. The indicator system will have to stay flexible as a response to new scientific knowledge on effects of climate change on regional land use. Some indicators of the recommended SEA-REP indicator concept will not be relevant to all German or EU regions. The applicability and efficiency of the indicators to a region's condition will have to be verified in practice. Some indicators will have to be further modified, supplemented or developed in the future to better address climate change effects and adaptation of land and resources under each region's future natural condition. The selection of LUCCA indicators was based on future scenarios for the development of the climate in most vulnerable areas in Europe and environmental objectives for adaptation to climate change (see chap. 3.3).

A SEA-REP indicator system, which is applicable in practice, should be based on consensus, achieved between the RPB and stakeholders, for instance in scoping meetings. The SEA team members should support transparency and openness concerning the practicability and scientific foundation of the concept. These factors are considered crucial to promote an environmental report, which the stakeholders and public understands and trusts. The competent team may comprise a variety of skills and disciplines, including besides regional or spatial planners, consultants in landscape planning, forestry, soil science, transport planning, hydrology etc. Each specialist should take over a well-defined role in specific phases of the indicator selection process. From experiences of transSEA the best working method for the indicator system is not linear but interactive and cyclic. Feedback and hints from scientific experts and practitioners across regional borders were considered, and in several cases led to revisions of the indicator system.

Quantifiable, Measurable and Reproducible

A prerequisite of indicators for SEA-REP was their measurability at the regional land use planning scale and their link to a time horizon of 15 to 20 years. All significant impacts of the REP contents

and all environmental media were adequately described. The emphasis of the analysis of SEA-REP case studies was put on quantifiable indicators, as these essentially contribute to a systematic assessment method and process in a partly unstructured regional planning culture in Germany. Quantifiable indicators and assessment thresholds generally reduce the risk of merely subjective decisions and misuse of bland alternatives and unsustainable land management. A systematic process potentially decreases the risk of subjective and arbitrary decisions, which cannot be sufficiently explained to the public, and therefore contributes to a positive acceptance of final decisions among the authorities and the population (Wiggering & Müller 2004). Experts, who demand a formalised environmental assessment based on a systematic quantitative indicator system, are concerned about the danger of unscientific non-transparent verbal-argumentative methods, which are often selected because of a lack of time and staff capacity. Subjective and often 'fuzzy' approaches can have severe shortcomings in logic, consequent and transparent SEA-REP, but often only verbal-argumentative descriptions, scenarios and functional relations or performances are available (Wüst et al. 1991: 6), which then have to be made transparent in the environmental report. SEA is characterised by a high level of uncertainty, and cannot be carried out as rigorously and quantitatively as EIA (Wood & Djeddour 1992 cit. in Jones et al. 2005b: 34; Lee & Wood 1995; Hilden & Jalonen 2005). However qualitative assessments can be equally valid and appropriate in SEA (Sheate et al. 2001: 2; Verheem 1992; ODPM 2005a). Decision-making will anyway also be influenced by subjective evaluations based on experience of regional and environmental planners. In transSEA qualitative assessments of the state of environment were classified and measured quantitatively in area sizes of the affected area and impact zone. Available 'hard data', which enables the RPB to make detailed quantitative predictions, was deemed to be particularly useful in the case where REP effects were uncertain, close to a threshold, or cumulative.

Environmental Media and Environmental Objective-Orientated

The indicator selection was based on two procedural approaches of a top-down- and bottom-up-approach. In the top-down-process key indicators were derived from existent environmental quality objectives and environmental quality standards of relevance for regional planning (see chap. 2.3). The bottom-up-process in contrast commenced at current environmental baseline data and at indicator systems, which were already approved in practice.

The environmental data could not be assessed without environmental objectives. All essential environmental fields and ecosystems should be recognisable with the indicator system, which should allow for statements on the degree of the environmental-political achievement of objectives (Jänicke & Zieschank 2004: 52f). An essential aim of the indicator system was to make conditions historically and regionally comparable to environmental objectives. The integration of environmental quality and action objectives into the development of environmental indicator systems, with the aim of a connection of status-quo-values with target-values, was strongly recommended by environmental experts in literature (e.g. BayStMLU 1998a, b; NLÖ 2001; SRU 1998, 2000).

On the one hand some necessary baseline data was not available in a sufficient quality and in a desired level of detail (e.g. maps on brownfields at regional scale), on the other a useful indicator system had to be able to satisfy the demand for practicability and transparency. Therefore both approaches of top-down and bottom-up were following parallelly (SRU 1994, 1998).

Since a strong link to the precaution principle and overall principle of sustainable development is required in SEA (Thérivel 2004), LUCCA indicators provide an early warning of potential problems and action fields of climate change. Most indicators for climate protection used in analysed SEA case studies (e.g. Reinke et al. 2005b; PGW 2002; Schmidt et al. 2004; RP Gießen 2006) and other sustainability indicator systems (e.g. ITA 2000; GFG 2002: 37) measure the achievements of the environmental objective of 'reduction of greenhouse gas or CO2 emissions' and 'increase of share of renewable energy production' in a region. With LUCCA additional indicators for the assessment of conflicts with adaptation of regional land use to climate change shall be implemented into indicator systems in the course of a long-term feasible strategy.

The LUCCA module is also a tool to raise public awareness on the adaptation of regional land use to climate change, as communication is a main function of indicators (EEA 1999). LUCCA are ideally understandable for the RPB, all stakeholders and a wide public. They are suitable to communicate and pass on the objectives of a stricter sustainable development in the context of climate change. Therefore LUCCA indicators simplify a complex reality and focus on the specific issue of physical land degradation.

Compatible with Existent International and National Indicator Systems

The indicators were selected from approved environmental state, impact and pressure indicators. In ideal circumstances available indicators already proved to be suitable, applicable and realistic for environmental assessments, including financial, time and staff capacities in the past. In favour of a transparent development of the SEA-REP indicator system its positioning within the current indicator landscape was made transparent in the planning process. The SEA-REP indicator system is on the one hand compatible with the specific problems and environmental settings of the respective region of OL-NS, on the other it is linked to existent EU, national and regional (sustainability) indicator systems (Walz et al. 1997: 50, 62; Köckler 1997: 27; Diefenbacher et al. 1997: 77ff, BMU 1997: 342, 2000; UBA 1997b; BUND and Misereor 1996). Existent regional concepts have the advantage that they are already integrated in the spatial scope of the regions and do not have to be newly developed (Gustedt et al. 1998: 48). Wiggering and Müller (2004) pointed out that already existing concepts have the advantage to be built on a widely scientific consensus, and have already been applied and tested several times. Several authorities and authors analysed and discussed the variety of existent indicator systems in comprehensive studies (see for instance Wiggering & Müller 2004; Gehrlein 2003; Weber-Blaschke et al. 2002; Pfister & Renn 1996; Heiland et al. 2003). The clarification of the status of the SEA-REP indicator systems in current indicator concepts was useful, in order to increase the acceptance of regional planners.

The SEA-REP indicator system is compatible with the international sustainability indicator approaches of the Organization for Economic Cooperation and Development (OECD) and United Nations Commission for Sustainable Development (UNCSD). The PSR approach of the OECD is internationally widely applied and therefore promotes a good acceptance of the defined indicators in the international context (BMU 1997: 186 ff). According to SRU (1998) indicator systems must put a clear emphasis on problem areas (OECD approach) or protection objectives (UNCSD approach). The consideration of environmental media only is not sufficient. The method of the OECD (1994) with pressure indicators (impacts on the environment), state indicators (the environmental state and quality, which changes directly or indirectly under the pressure of

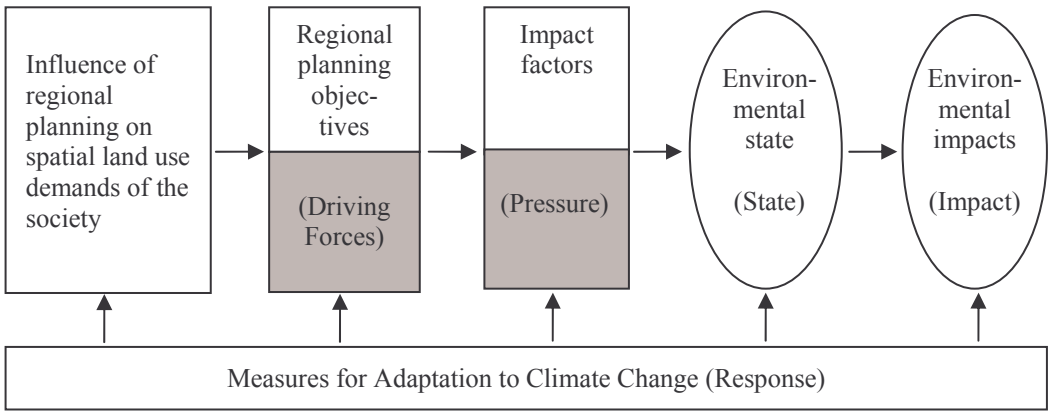

Figure 21: Integration of the DPSIR approach of the European Environment Agency into strategic environmental assessment

anthropogenic influences) and response indicators (reactions of societies), which is structured after problem areas such as climate change, is adequate for SEA-REP (see figure 21). The PSR framework presents the essential connections between human activities and the state of environment, and can therefore make long-term predictions for sustainable development (similarly UNCSD 1996, 2006; EEA 2000, 2004, 1999; EUROSTAT 1999). However, this approach does not adequately consider the issue of physical degradation and the adaptive capacity of the environmental media yet (OECD 2007) and should be extended and differentiated concerning international adaptation policy.

In this SEA-REP indicator system the ‘environmental state indicators’ are defined as current environmental qualities including initial pollution of the individual environmental components of the environmental media. An example of an OECD state indicator of the region’s woodland development is ‘the increase of woodland area’. Whilst the OECD indicator function is to monitor the state of the environment, in SEA-REP indicators shall first of all assess environmental conflicts. The process of improvement to achieve an environmental target can be considered in the monitoring of the regional plan implementation in SEA-REP. Pressure indicators can measure the land take originating from industrial sites, state indicators would describe for instance the soil quality of an affected area (environmental component) – in other words, they measure the carrying capacity of ecosystems as a sink (Franke & Kottmann 1996: 120) – and response indicators can be measured for the protection of the climate, e.g. the adaptation of regional planning to climate change using SEA-REP as a driving force. The borderline between ‘environmental state indicators’ of SEA-REP and state, pressure and response indicators after OECD is not always clear and an accurate distribution is not possible. The difficulty of a classification of indicators increases, the more the PSR system orientates at cause-effect-chains (Walz 1997: 232). These are simplified in SEA-REP with impact factors affecting environmental components and LUCCA. For example ‘contaminated areas’ can be classified as pressure indicator; ‘protected areas’ can be identified as response indicator. The overall objective of the selection of environmental state indicators is to focus on the status quo of the affected area and its distance to environmental targets.

Scientifically Robust and Credible

The SEA-REP indicator system was developed under scientific advice as a regional-specific and participatory system, which is linked to a problem context in the same way as traditional regional sustainability indicator systems (Gustedt et al. 1998: 30). Its focus lies on environmental and climate change issues. The development of the assessment method in transSEA was accompanied by transdisciplinary scientific advice and an application in practice.

Capable of being Monitored to Show Regional Trends over Time

Through the foundation on assessment thresholds from the assessment of the state of the environmental media in the region, the indicators are based on well-founded scientific concepts and sufficient empiric investigations of model calculations (Jänicke & Zieschank 2004: 52f). An advantage of quantitative values is, that regions can be better compared in their performance of adequately taking environmental media and environmentally sound land uses for the mitigation of negative impacts of climate change into consideration in SEA-REP (e.g. by creation of the ratio between the current state of environment and future state of environment: deforestation area/afforestation area)). The methodology for derivation of state indicators and assessment thresholds can be ‘standardised’ for each region of the EU Member States. The result will be a comparable basis for certain regions of a part of a country for the impact assessment, compilation of environmental quality objectives and environmental quality standards, comparison of alternatives, monitoring and review in SEA-REP.

User-Friendly and Justifiable in Effort and Costs

The indicators should be well understandable, transparent, flexible and simple to be interpreted in public. For the complex task of the assessment of impacts of REP contents the quality of the environment or its elements could not be represented with a single aggregated indicator or index, but had to be represented by a larger number of indicators (Fürst et al. 1992: 30). At the same time, the complexity of the reality was reduced in order to make the indicator system practicable and applicable in SEA-REP. Due to various interrelations of social and ecological processes it was appropriate to reduce complex data through a selection of only a few, meaningful and representative measuring values (guidance indicators) and in this way to generate a simple replication of reality (BMU 1997: 339). A compromise was striven for in consultation with authorities, between what were adequate contents of the assessment at the scale and on the level of detail of regional planning, and what was still applicable in practice for the RPB OL-NS. LUCCA were later introduced as a response to first of all missing state indicators of special significance in current public discussions and environmental problem fields. Climate change is currently (in 2008) considered a pressing concern. The values of the society are permanently subject to change. Therefore it is important that the indicator concept stays flexible and open to changes through environmental policies, changed environmental components and individual indicators as well as the assessment methodology. Other reasons are that the state of environment in a region, sustainability objectives and knowledge gain on climate change impacts are no static but dynamic parameters.

The efficiency of costs of the application of the selected indicator system will have to be evaluated in practice in different case studies. No statement can be made on the transSEA pilot project, as parts of the SEA and research were carried out with the help of EU and federal funding.

4.4 Assessment Thresholds of Conflict Intensity

The core step of the site-specific assessment of REP impacts is a comparison of the status quo and regional environmental quality objectives, i.e. a set relation between the described state of the environmental component including LUCCA and the set regional targets, independently from which legal or planning source the targeted state is obtained from (Fürst & Scholles 2001: 292; Scholles & Kanning 2001: 117). The two values 'impact factor' and 'state of the environmental component on the affected site and impact zone' were combined with the help of impact and state indicators and assessment criteria to a conflict class (figure 22).

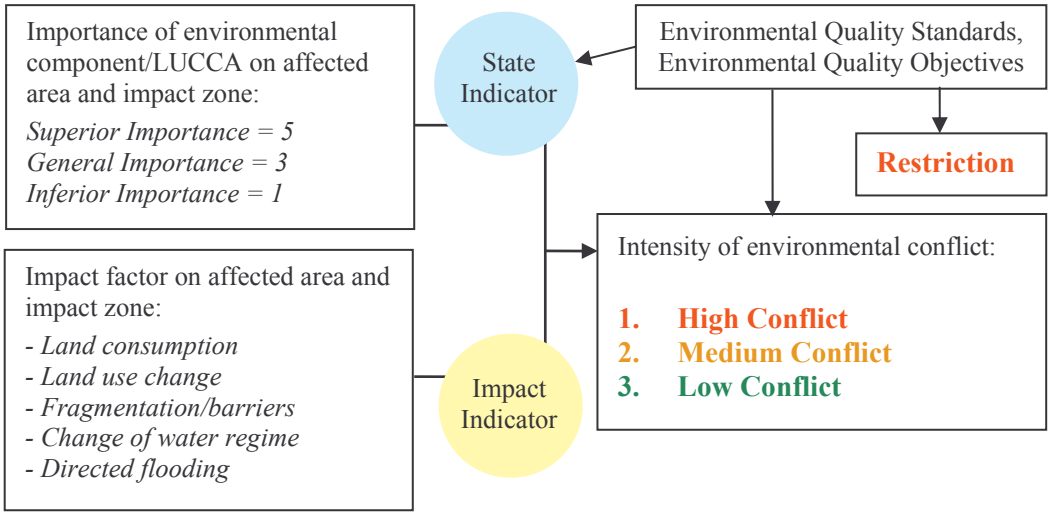

Figure 22: Analysis of environmental conflict intensity for LUCCA in SEA-REP

4.4.1 Strict Legally-Binding Restrictions

Land uses or environmental components, which are strict-legally protected against any adverse effect, are assessed as 'Restriction'. These are mainly protected sites or legal exclusion zones, where negative effects are prohibited by law such as national nature reserves or where a certain level of environmental quality must be preserved according to environmental legally binding standards (see chap. 2.3.4). With additional impacts on a specific site there is a risk that threshold values and environmental objectives will be exceeded (respectively 'broken').

However, in regional planning a differentiation between descriptive indicators (e.g. biotope types of region, unfragmented areas etc.) and normative statements (e.g. special protected biotopes, unfragmented areas > 100 km^2) is not always possible, mostly because only highly aggregated environmental data is available (Jessel 2005).

Table 6: Example of restrictions

Indicator	Restriction
LUCCA 1	Strict legally protected green spaces in urban areas
LUCCA 2	Internationally or nationally strict legally-binding protected natural and recreational areas; Climate protection forest, immission protection forest
LUCCA 3	Restrictions of strict legally protected recreational sites
LUCCA 4	Protected retention areas and floodplains Protected ecosystems and biotope types
LUCCA 5	Protected special protection areas (SPA) and habitat preservation areas including their buffer zones, habitats and species of Annex II and IV of the EC Habitat Directive, Annex I of the EC Wild Birds Directive; National nature protection areas: national parks, nature reserves, biosphere reserves (zones 1 and 2), protected landscape elements, protected biotope types; areas with occurrence of Red List species; Unfragmented areas > 100 km^2 (in Germany).
LUCCA 6	Natural woodlands protected as SPA (Habitat and Wild Birds Directive), national park, biosphere reserve (zone I), nature reserve, landscape recreation area (BNatSchG); Climate protection and recreation forests (Art. 12, 13 BWaldG)
LUCCA 7	Biotope types of Annex I of Habitats Directive; Nationally protected biotope types.
LUCCA 8	Strict legally binding nature protection sites, protected biotope types, landscape protection areas, groundwater protection sites (core zones) etc.
LUCCA 9	Currently no strict legally-binding environmental standard exist.
LUCCA 10	Erosion protection forests
LUCCA 11	Water protection areas; Protected drinking water catchment areas zones I and II; Groundwater sanitation areas.
LUCCA 12	Water protection areas, protected biotope types

4.4.2 Uncertainty of Predictions and Remaining Risks

Environmental precaution involves the awareness and consideration of uncertainty of information and predictions in SEA-REP and being ‘open about uncertainty’ with the stakeholders (Stewart 2004: 2). At the strategic higher planning level with a long time horizon, larger spatial scope, smaller scale of 1: 100 000, and more abstract information, consequences of impacts on the environment on the natural resources and land use in a region stay uncertain and partly subjective, despite intensive scientific research (Petts 1999). Even a large quantity and high quality of scientific knowledge and data cannot overcome uncertainty of impact prediction and decision-making in SEA-REP. A first method of dealing with uncertainty in SEA-REP involves the determination of impact zones and minimum distances (chap. 3.4.4). A second method is an environmental conflict analysis, which operationalises the relation between cause-effects-receptors adequately for the regional scale. It can be demanding for a RPB to decide, which level of

optimisation of a regional plan in the SEA process is adequate. An environmental conflict analysis can explicitly take account of and inform about uncertain future outcomes of the implementation of a regional plan. For the determination of the probability of occurrence in SEA-REP a lot of information and experience would be required in tiering and the realisation of plans (Scholles 1997; Balzereit 1999: 20f). In transSEA not sufficiently known were losses during transferability of knowledge from other case studies, cause-effect-chains, especially sensitive receptors and cumulative effects. As experience was not available in transSEA, a post SEA-REP monitoring concept should audit, if the significance of the REP impacts was accurately predicted, assessed and mitigated. It should be analysed during the SEA process, if the level of uncertainty can be reduced by collecting more or different information and if further techniques for reducing and communicating uncertainty can be implemented. These are for instance predictions in terms of ranges rather than precise figures, predictions based on different scenarios, worst-case scenarios based on the precautionary approach, contingency plans or sensitivity analyses (EN 1996).

4.4.3 Ranges of Precaution, Concern and Harmful Effects

Assessment criteria in form of thresholds were derived for a classification of the environmental conflict intensity, caused by regional plan designations affecting the assessed importance of the environmental components. The aim of the environmental conflict analysis is to classify risk levels of significant impacts of the regional plan on the affected area and impact zone. The assessment of environmental conflicts shall determine the level of acceptability of the risk, caused by the implementation of the regional plan, and the need for mitigation and adaptation measures to avoid/prevent or limit/minimize this risk. These strict legally-binding limit or guidance values, defined by the SEA team on the basis of available environmental quality objectives and environmental quality standards or precautionary values, function as upper and lower borders of three ordinal classes of conflict intensity:

- unaccepted concern ⇨ High conflict;
- undesired harmful effect ⇨ Medium conflict;
- remaining precaution ⇨ Low conflict.

The assessment thresholds to be applied in SEA-REP were with priority normative values from legal norms and administrative regulations. In a second step, if for certain environmental impacts no specific thresholds fixed in legislation were suitable, legal thresholds were used, which are not directly pertinent because of their application scope, but have factually comparable impacts on the environmental media. The transferability of these values was estimated qualitatively by the SEA team. In the case where no normative thresholds were available non-sovereign environmental guidance standards were drawn on under consideration of their actuality (Albert et al. 1998: 20f). Guidance values were defined as a certain degree of harmful degradation of the environmental components without legally binding character, which was considered by the experts as a critical level, estimated on the basis of the current carrying capacity, sensitivity or adaptive potential of the environmental component. They are not binding, but represent a subjective expert statement (Kohn-Schulze 1996). Their purpose is to integrate a precautionary range for future impact situations. They shall initiate a region-wide analysis of causes of physical degradation and contribute to the target-oriented setting of mitigation and adaptation measures. The application of

precautionary assessment criteria for SEA-REP is a response to Art. 174 para. 2 EC Treaty (Kläne & Albrecht 2005: 19) and the German EIA Act, which demands:
"The competent authority shall assess the project's environmental impacts (...) and shall take into account this assessment when deciding upon approval of the project with regard to efficient prevention of environmental damage (...) pursuant to the applicable laws" (Art. 12 UVPG).

The objective of the precautionary principle is to avoid environmental impacts through preventive measures (Müller & Wiggering 2004: 7; Peters 1994: 85). The overall objective of an anticipatory adaptation is to "*focus more on prevention, early warning and preparedness*" (EC 2007a: 18). The implementation of preventive measures means for regional planning, that during the designation of land uses the carrying capacity of the environmental media must not be exceeded (Gustedt et al. 1998: 15), but instead sufficient area with an environmental potential of high and moderate importance in the region is safeguarded for future generations. The aim is thus to achieve a regional plan, which is acceptable and long-lasting from the perspective of the environment. However, it is not the aim of SEA-REP to come to a result, that a regional plan is not environmentally-friendly. Therefore precautionary action can be a preferred strategic alternative. It is required to anticipate future effects and taking preventative action for protection of the environment, before these effects take place. It is not necessary to have the scientific evidence that (irreversible) harm will definitively occur from certain regional plan designations with their implementation at the project level, but a likely significant impact is sufficient to install the optimum effort for preventing, mitigating and monitoring this impact (UNCED 1992, chap. 35 para. 3).

Increasing level of risk	Impacts on the environment	Criteria
unacceptable	Area of Harmful Effects ⇨ A harm or loss of the environmental component is likely. Environmental quality standards (assessment limits)	⇨ An exceedance of environmental quality standards (protected areas with strong legally-binding character, environmental quality standards, limit values and precaution-oriented guidance and threshold values) is legally prohibited or environmentally unacceptable. Example: land consumption of an arable land with high soil quality is considered as a high conflict.
undesired	Area of Concern ⇨ A harm or loss of the environmental component will be likely in future in the case of progressive adverse impacts. Environmental quality objectives (precaution limits)	⇨ An exceedance of an environmental quality objective or environmental action objective cannot be recommended from the point of view of the environment. Example: land use change of an arable land with moderate soil productivity is considered as a medium conflict.
remaining	Area of Precaution ⇨ The environmental component is not adversely affected in its existence or functions.	⇨ No exceedance of environmental quality standards or environmental quality objectives. Example: Land consumption on an area > 50 % sealed is considered as low conflict.

Figure 23: Areas of environmental risks
(Sources: applied from Hoppenstedt & Riedl 1992; Bechmann 1994; Scholles 1997; Obst 2005)

Uncertainty and lack of knowledge on complex causal interrelations are reasons for the determination of precautionary medium ranges of conflict intensity. A classification of the conflicts into a minimum of three classes (high conflict-medium conflict-low conflict), which were derived for the three ranges of precaution, concern and harmful effects, was considered as being suitable for SEA-REP (Figure 23). Tiering is necessary for more detailed assessments of the importance of the environment on the affected area at land use planning level.

4.4.4 Methodology of Conflict Analysis and Classification

Each regional plan impact was cross-linked with a superior, general or inferior importance of the environmental component on the affected area, and was accordingly classified into one of the three conflict classes. The area of harmful effects represents a not acceptable risk for the environment, which has to be avoided. The area of concern covers adverse effects on the environmental media, which are not harmful yet, but additional impacts must be prohibited. For pollution of environmental media with substances strict legally-binding standards exist, which define the threshold between area of concern and area of harmful effect. For physical degradation such a strict value does not exist. The border-lines between these classes are not strict, but rather fuzzy. The ordinal scale implies that not all conflicts of the same conflict class are of the absolute same environmental risk in realty. The classification into three classes is rather broad, but was considered to be sufficient for the regional planning level with the overall planning objective of precaution. Each class' width should be wide enough, in order to avoid too small inputs for the classes. If it is unknown, which maximum or minimum value an investigated parameter may have, the upper or lower class has to stay open to the above or below. Examples are exact soil sealing values, which can only be assumed at regional planning level. Classifications generally lead to a loss of information and are characterised by fuzzy border zones. The less aggregated and the more original values are used, the better for the transparency of the assessment. As the borders of the classes are not strict and clear, they mainly assist in getting results of conflict intensities, which can be used as recommendations for the decision-making of the RPB. Case-by-case analysis in a respective region will always stay necessary.

The classification of ordinal environmental conflict classes (figure 23) had to fulfil three minimum formal requirements:

1. unambiguity, i.e. each measured value can be distributed to a class;
2. exclusivity, i.e. each value fits only into one class and not several classes; and
3. integrity, i.e. both previous requirements are fulfilled, thus no value exists, which cannot be distributed to any class.

Instead of risk classes, three conflict classes (high conflict – medium conflict – low conflict) were selected, because the term 'high risk' could be misunderstood, as it implies that an impact could still be more harmful, as the class is open to the top. For instance in the case of land consumption, followed by a designation of an urban area on high productive soil, the impact will occur with a high certainty, as there exists a need for housing in the municipality. In this case the state of environment on the affected area will be irreversibly harmed and no risk remains (Jessel & Tobias 2002: 254f). Such a risk is an 'unacceptable risk', which is distributed to the class of high conflict, which is equal to the area of harm in figure 24.

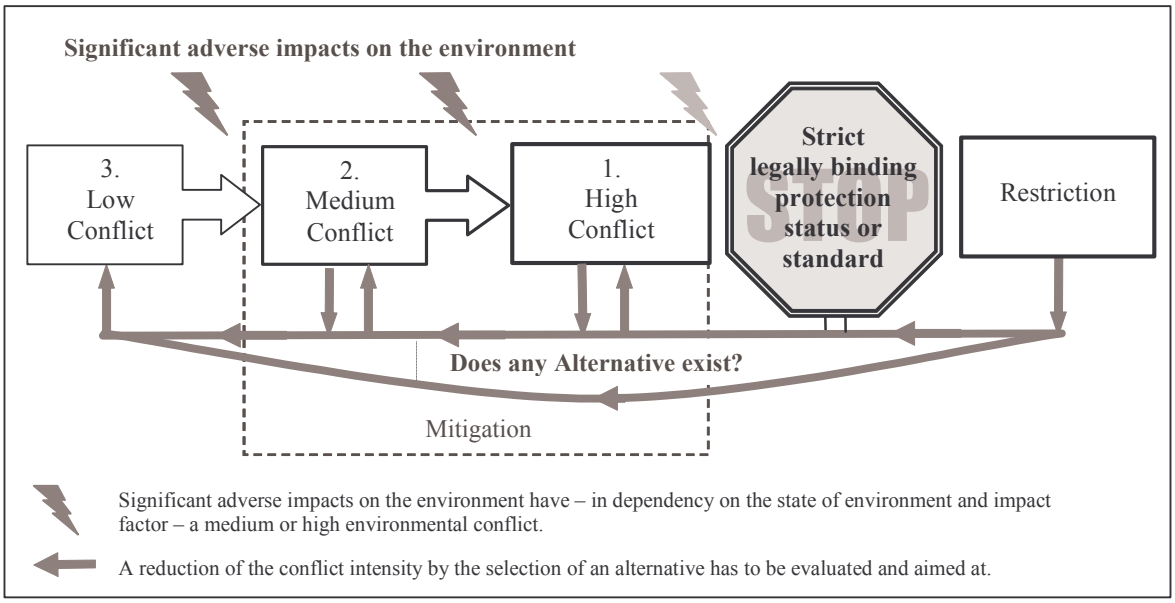

Figure 24: Classes of environmental conflict intensity

The first class (1.) 'High Conflict' categorises areas with a high potential for conflicts. Affected are environmental components with a high ecological (and social) value, where significant effects are likely to happen. Predicted impacts may lead to harmful effects on the environment with sufficient probability.

The second class (2.) 'Medium Conflict' characterises a medium potential for conflicts between impacts and the environmental value of the area. This medium rank is necessary in order to steer 'High conflict' developments towards environmentally more resistant locations and/or away from sensitive areas according to the precautionary principle (comparison of alternative sites). It is also of importance, in order to determine early impact mitigation and climate change adaptation measures with the aim to keep future costs and effort for the prevention, mitigation and reaction on natural catastrophes and hazards as low as possible.

The third class (3.) 'Low Conflict' categorises conflicts without significance due to the inferior importance of the state of the environmental component on the specific site. Even if higher intensities of degradation always mean the classification of a higher conflict, a zero conflict can only be assured in a complete absence of degradation. A residual risk remains in this precaution area, as the knowledge on or state of the environmental media and impacts of regional plans can change.

The assessment of every single site (see chap. 4.4.3) is necessary to be able to compare site alternatives and find the least possible environmental conflict. Each impact may lead to a decrease of the environmental potential of a site and thus to an 'upgrade' in the conflict classification. Alternative site selections have to be considered especially in the case of 'High conflicts'. Additionally mitigation, adaptation and compensation measures have to be evaluated and documented in the environmental report.

The determined impact factors (see chap. 3.4.3) were first of all treated equally in the conflict analysis, which means, no range of their environmental relevance was determined. This is a

difference to a classical ecological risk analysis. The reason was, that it is irrelevant, which impact factor affects an environmental component, as the result is first of all a general loss or degradation of the status quo on the affected site or impact zone. This degradation conflicts with environmental quality objectives and environmental quality standards. A more detailed assessment must take place in SEA of land use planning at lower tier. It was deemed sufficient to distinguish between different impact factors in the overall assessment of the regional plan and post SEA-REP monitoring step, where the tendencies in a region are made transparent (e.g. the total area or area share of an environmental component or LUCCA lost by land consumption). In a second step the transSEA expert team decided to distinguish case-by-case between different impact factors affecting the same area, e.g. between land consumption and land use change. The decision on a higher or lower conflict class was based on an estimated higher or lower sensitivity or importance of an environmental component towards a certain type of impact. For instance, a change of the water regime was estimated to be more significantly harmful for the groundwater development rate than a land use change from agricultural land to forested land. This methodology was based on professional experience and judgement. However, such a differentiation of the weight of impact factors should be well justified in the SEA report.

4.4.5 Results and Summarised Assessment of Environmental Conflicts

The spatial and temporal boundaries of all site-specific REP designations were linked with the importance of the state of environment for each relevant environmental component and strict legal restrictions. Each site-specific assessment will result in a restriction, high to low conflict or positive impacts for each affected environmental component and LUCCA. All restrictions and conflicts on the affected areas and impact zones were identified with map overlay, measured in square kilometres or hectares, and presented in conflict maps. A conflict map allows a quantitative statement on the total area or area share of an environmental component affected by a certain impact factor, or on the distance-to-target of the regional plan implementation from environmental objectives of relevance for a region (PVB 2005, 2006; Stock & Gründler 2004). The conflict maps highlight regional plan designations of high and medium conflict intensity in the region and represent an incentive for the regional planning authority to avoid, mitigate or adequately justify a deviation from environmental standards or objectives. A transparent identification and visualisation of spatially-related environmental conflicts strengthens the position of environmental concerns in the weighting process of regional planning, so that an ‘overweighting’ in favour of economic concerns becomes more difficult (Helbron & Schmidt M. 2008: 417).

It can be distinguished between three possible results of the site-specific impact assessment:

A) The realisation of the REP designation is preventive and does not lead to future harm or danger:

- only ‘no conflicts’ or ‘low environmental conflicts’ were analysed;
- no environmental components of special or general importance or restrictions were affected;
- the balance of the status quo and the future environmental potentials in the region present no deviation from environmental objectives.

B) The realisation of the REP designation is harmful to a certain extent:

- at least one ‘medium environmental conflict’ was analysed;

- mitigation and compensation measures were implemented.

C) The realisation of the REP designation represents a danger to the environment:

- at least one high conflict with or without restriction of the realisation of the REP designation was analysed;
- predicted negative impacts cannot be mitigated or compensated on lower planning levels;
- a deviation from environmental objectives cannot be mitigated or compensated.

In order to simplify the comparison of alternatives these conflict intensities were summarised for each environmental media and site or impact zone. A classical aggregation or a single scale of all environmental state indicators was not possible, as the references and values for the assessment are not the same (Jänicke & Zieschank 2004: 59; Karl & Klemmer 1990: 32). Also an overall aggregation of all conflict areas for the regional plan, e.g. the more conflicts of higher intensity are counted, the higher is the resulting problem, could not be undertaken due to methodological constraints. Instead three types of summarised assessments were possible:

1. summarising the conflict intensities of different impacts on one environmental component or respectively LUCCA;
2. summarising the assessment results for one environmental media;
3. summarising all conflict intensities for one specific site or impact zone.

During any summary of results additional verbal arguments were necessary for decision-making and it was important that:

- the area share of different conflict intensities at the total affected site or impact zone stayed transparent;
- particularly high conflicts with and without restrictions stayed transparent;
- the individual summarised environmental components stayed transparent.

The area size of ‘high conflicts’ or ‘medium conflicts’ could not always be the only criteria for a site comparison. Additional expert knowledge on the affected areas in the region and verbal arguments were needed. The result was a ranking of alternative sites in the frame of sustainable spatial development after weighting with socio-economic concerns – not necessarily always the best environmental alternative.

4.5 Comparison of Alternatives

The SEA report should according to Annex 1 lit. h SEA Directive include the method, process and reasons for the consideration and selection of reasonable alternatives. This covers reasons for the designation or rejection of all proposed and assessed site-specific alternatives and any criteria for the selection of conceptual alternatives. Alternatives were considered as reasonable, if they agree with the scope and objectives of a regional plan.

As the draft report should represent an efficient basis for the consultation of authorities, public participation and the decision-making process within the RPB, it is not sufficient to document only alternatives in favour (Kreja 2004: 131, 297). A transparent and well structured documentation of the no action-alternative and any other alternative proposed and their comparison is required (Jacoby 2005: 29). However, German regional planners often do not have the competency to directly decide on whether a REP designation or objective is necessary. They for instance only

spatially implement a national or federal targeted area share and production capacity for renewable energies in a region. Questions of no-action alternatives or weather a certain objective is necessary or adequate require Policy SEA and SEA of the higher state land use plan. However, regional planners may be able to decide to fulfill higher policies to less than 100 % as response to regional-specific tendencies, e.g. land use or global climate change. The RPB should also document socio-economic reasons for the proposal or non-proposal of different options and alternatives and essential pro and contra arguments of the comparison and final proposal of alternatives.

SEA supports the identification and comparison of options for future land use designations under consideration of different partly conflicting concerns of land uses. It allows the comparison of alternative area sizes and conflict intensities. Typical regional designations with a potential for a comparison of site alternatives in SEA-REP are mining sites, afforestation areas, urban settlement areas, industrial/commercial sites and wind farms. These designated areas generally are suggested in great numbers and therefore a selection of a certain number can take place and other areas can be held back until the amendment of the revised regional plan. Several designated areas can be compared and the ones with the lowest environmental conflict intensity can be designated. Perhaps with the next generation of the regional plan, the need for further mining areas will have changed, as the energy supply by renewable energy sources will have improved in efficiency. Areas with less harm or risk for the environment can be designated in the current REP.

A comparison of alternative sites involves an addition of all conflict classes of each environmental component of one environmental media for each alternative site. Table 7 presents a general checklist for the comparison of four alternative sites and their conflicts with LUCCA. This checklist could be further developed through a differentiation between affected area and impact zones and a consideration of all area shares of the three conflict intensity classes (PVB 2006). Additionally to a quantified comparison expert knowledge on the affected areas in the region and verbal arguments will be needed. The result will be a ranking of alternative sites.

Table 7: Example for a comparison of alternative sites for environmental conflicts with LUCCA 1-12

(Source: modified from Stratmann et al. 2007b)

Alternative Site	Area size in ha	Land Uses of Importance for Adaptation to Climate Change												Sum	Range of sites
		LUCCA 1	LUCCA 2	LUCCA 3	LUCCA 4	LUCCA 5	LUCCA 6	LUCCA 7	LUCCA 8	LUCCA 9	LUCCA 10	LUCCA 11	LUCCA 12		
A	80	1	1	1	1	1	2	3	1	1	2	1	1	4	3
B	80	1	1	2	1	1	1	3	1	1	1	1	1	3	2
C	20	1	1	2	1	1	1	1	1	1	1	1	1	1	1
D	14	1	1	1	1	1	3	3	2	1	3	1	1	7	4
=	194	1	1	3	0	0	3	6	1	0	3	0	0	15	

3 (!)	Restriction	2	Medium conflict
3	High conflict	1	Low conflict
		0	Positive effect

Further alternatives to be assessed in the overall strategic assessment of SEA-REP are alternative prognosis of needs and conceptual alternatives, which for instance contribute to a reduction of the need to travel, waste production, transportation or energy consumption in the entire region (Stratmann et al. 2007a; Jacoby 2000; Schmidt C 2004). The assessment of conceptual alternatives serves the optimisation of the selection of the location for the REP designations and the prevention, avoidance, minimization and compensation of negative environmental impacts. Selection criteria for the conceptual alternative sites can be: minimum areas, minimum space distances, concentration of specific designations in one area; or restriction of specific designations in sensitive natural areas. Jacoby (2004b) distinguishes between:

- potential alternatives: area-wide analysis of the potentials of alternatives, building site or location potential, under consideration of ecological, economic and social concerns;
- concept alternatives: alternative development scenarios, land use models or location concepts on the basis of analysis of demand and the results of the potential analysis with the help of a summary investigation of the environmental impacts and an estimation of socio-economic consequences;
- location alternatives: comparison of locations, areas or site alternatives with a detailed investigation of environmental impacts and socio-economic consequences.

In an overall assessment for all environmental components and LUCCA, single assessment fields cannot be set off against each other. For instance a gain of area of LUCCA 1 cannot balance out a loss of area of the same size of LUCCA 2. "*Such an assessment requires a weighting of different assessment themes and therefore is part of the weighting process of regional planning*" (Recktenwald 1994: 93). Scenarios of different types of conceptual alternatives can be compared, such as an evenly spread out distribution of urban settlements in the region versus a concentrated designation of settlements in specific municipalities with lower impact on highly productive soils. The final result of regional decision-making should be ideally sites or strategic options with the least possible negative effect on the environment and global climate and the best compromise between conflicting objectives.

4.6 Implementation of Mitigation Measures

An essential objective of the SEA process is to reduce conflict intensities during the making and revision of a regional plan before it is published, and to recommend more detailed investigations on a lower planning tier, where more specific and accurate information is available. Annex I lit. g SEA Directive defines mitigation measures as "*the measures envisaged to prevent, reduce and as fully as possible offset any significant adverse effects on the environment of implementing the plan or programme*". In other words, mitigation aims to avoid adverse impacts, minimise any negative impact, optimise any positive ones, enhance sustainability and the adaptation to climate change in other ways if possible, and ensure that proposed mitigation measures do not themselves cause negative impacts (EC 2003). Williams (2005) clearly defined mitigation as "*the activism to protect nature from ravages of human activity*". Consequently, the earlier in the planning hierarchy

spatially-relevant environmental conflicts are avoided[23], mitigated or compensated, the better in an environmental, social and economic sense.

SEA-REP ideally creates a decision support for the reduction of land consumption or degradation, and for the mitigation of cumulative impacts for instance with the help of minimum distances, in order to avoid clusters of intensive developments and to prevent protected or sensitive land uses from danger or harm. A permanent communication flow on mitigation measures top-down and bottom-up will contribute to an improvement of SEA efficiency, as it gives the chance to react on lessons learnt. Mitigation plays a very important role in setting guidelines for development and resource management in SEA-REP. The RPB should on the one hand mitigate the negative impact of regional plan contents on the global climate (see chap. 3.3.3), on the other integrate effective methods to decrease the environmental conflict intensity, which will be changed by the climate over the regional plan's lifetime, into the regional plan. The first task is particularly important for mitigation of GHG emissions. It should also be carried out for the mitigation of physical degradation of all environmental components, and specifically LUCCA, with the help of a site-specific and overall assessment of the regional plan. The second step may include – beside the designation of conventional priority areas for remediation of soil, water, nature and landscape, agriculture or forestry – new plan designations of priority areas of land uses with special importance for mitigation of effects of climate change through carbon/water capture and storage, or priority areas with special importance for the adaptation to climate change.

4.6.1 Mitigation of Physical Degradation

The implementation of mitigation and adaptation measures to protect LUCCA against physical degradation should gain more attention in regional plan-making. During the entire SEA-REP process – from the announcement of the amendment of a regional plan, over the preparatory draft to the final REP draft – mitigation measures for degradation should be analysed, catalogued and as far as possible implemented. Especially cumulative impacts with climate change and impacts of other plans and programmes should be mitigated. The types of potential mitigation measures at regional plan level will depend on:

- the REP designation (own objective or integrated from sector);
- the type, significance, irreversibility and timely/spatial scope of the impacts;
- the regional importance and vulnerability of the affected LUCCA; and
- the political willingness of the RPB to reduce adverse effects on the global and regional environment and human health.

Regional land use planning shall with priority prohibit environmentally harmful activities in certain areas and confine unavoidable land degrading activities to clearly demarcated geographical areas or sites where no particularly vulnerable targets exist. It thus is an important means of singling out and protecting areas that are vulnerable or particularly important from an ecological point of view (Koning 1987: 55; Lee & George 2000: 90). If activities conflicting with LUCCA are systematically confined to particular regions, the RPB becomes a planning agency for decisions,

[23] Prevention saves money, effort and time and reduces the risks of hazards and technical failure.

which are potentially in favour of adaptation to effects of climate change, as the physical degradation potentially most important land is reduced. Regional land use planning should aim at avoiding 'adaptation constraining decisions', i.e. decisions that conflict with the management of climate risks in the future. These are for instance progressive land consumption, loss of high quality agricultural soils or inappropriate development in flood risk areas. The ideal objective is to identify 'win-win options' that contribute to both climate change mitigation, adaptation and to regional plan objectives (CCW et al. 2004b: 7). Examples are new business opportunities from regional-specific sustainable produced agricultural food of high diversity or from renewable energy production. Box 9 lists some examples for mitigation measures for land degradation in SEA-REP. These present a framework for more specific and technical mitigation methods at lower planning tiers, which should be recommended in the environmental report.

Box 9: Mitigation Measures for land degradation in SEA-REP

Approach	Examples
Avoidance/ No-Action	Changing route or site details, to avoid important ecological features; No land consumption in floodplains, green or fresh air corridors; Removing designations from former regional plan, not yet implemented.
Replacement/ Substitutes	Regenerating a similar habitat of equivalent ecological value in a different location;
Reduction of the Conflict Intensity	Minimising loss of land with superior and general importance for adaptation to climate change by choosing an alternative site of inferior importance; Designating flood protection sites to reduce flood risks; Designating afforestation sites to reduce soil erosion risk; Designating a regional biotope network to minimise loss of biodiversity; Reducing cumulative impacts with buffer zones and time delayed designations; Relocating displaced urban areas or ecosystems.
Rehabilitation or Restoration	Designating areas for the restoration of nature and landscape; Designating areas for the remediation of soil, water and air.
Compensation	Designating compensation areas with environmental benefits for future affected most vulnerable environmental components; Regulating facilities for future affected most vulnerable communities.

Avoidance/No-Action

Often the best decision from the perspective of the environment would be the do-nothing-alternative. This would be for instance the avoidance of land consumption, land degradation, fragmentation, changed water regime or directed flooding by abandonment of existent REP development categories or of proposed designated sites (Glasson et al. 2005). In reality a justified socio-economic need for development denies the no-action-alternative. However, first of all any adverse impacts on strict legally-binding protected areas and other restrictions have to be avoided. Secondly other high environmental conflicts without legal restrictions should be avoided. The RPB should critically discuss the final designation of alternative sites, causing high environmental conflicts (with or without restriction) with several environmental components and LUCCA with all stakeholders and the public. Costly future relocating measures for ports, industrial sites and entire

cities and villages from low-lying coastal areas and floodplains are ideally avoided in advance (EC 2007a: 10).

Cases of priority of social or economic concerns, which lead to high conflicts with the regional adaptation to effects of global climate change, should be revised. Traditional regional designation criteria should be improved with the objective of a more consequent avoidance of new land degradation. For instance, no new urban developments in floodplains, in green corridors, fresh air corridors or on agricultural land of superior productivity should take place, if high conflicts are expected. Further fragmentation of large-scale unfragmented woodlands or biotope connection areas and corridors should be avoided.

In the region of OL-NS a higher objective from the Saxon land use development plan (LEP) (SMI 2003a) demanded that no new designations of urban settlements were integrated into the revised regional plan, as the region's population is continuously shrinking. One step further is the removal of formerly designated urban sites, which were not implemented at lower land use planning and project level yet, with the amendment of the REP (e.g. in Middle Hesse, RP Gießen 2006).

Replacement/Substitutes

For some LUCCA the creation of substitution areas should be foreseen, for instance for new areas of nature conservation or wildlife corridors that go beyond individual development sites (EN 1996). The RPB should be aware of the time lag between the current state of environment and targeted state of environment. The loss of land through degradation could be replaced by the designation of areas to be developed with the aim of an increase of their potential for carbon and water storage and further ecological functions, which are important for adaptation.

Reduction of the Conflict Intensity

The conflict intensity of an alternative site can be reduced by a modification of dimensions and functions of the REP designations: the size and/or shape of the planned area, the length of fragmentation lines, the percentages of rest area shares or the importance of a barrier effect. An essential measure to spatially avoid and reduce adverse effects on sensitive land uses, e.g. for living, recreation or nature conservation, is the designation of buffer zones, which create minimum distances between harmful sources and sensitive receptors. This measure is integrated into the regional plan-making by the use of impact zones as search and investigation areas in SEA-REP (see chap. 3.4.4). In REP buffer zones can combine minimum distances between conflicting land uses with a designation of new land uses, which further reduce adverse effects. For example afforestation sites can be designated with the objective of a reduction of multiplying noise, pollution and visual impacts, caused by a number of lignite abstraction sites, affecting nearby residential settlements, recreational areas or areas for nature conservation. During the designation of extensions of existent urban areas wind direction, landscape morphology, relief and predictions for future climatic conditions and storm events should be considered with the aim to reduce the risk of heat stress of the urban population or storm damages.

Rehabilitation or Restoration

The designation of ecological rehabilitation or restoration areas can be considered in the overall

assessment of the regional plan as mitigation measure with likely positive effects on the global climate. A restoration can be for instance the conversion of former mining pits to sustainably managed forests or recreational areas.

Compensation

The purpose of regional plan designations for the compensation of impacts is to replace or minimise unavoidable significant impacts affecting the carrying capacity of the environmental media. REP can create the framework for future compensations in form of urban open spaces to be developed as recreational sites, which compensate the development on brownfields, or even financial compensations for resettlements of people from coastal zones or floodplains at project level. In priority areas for adaptation to climate change preventive compensation measures may be more appropriate, than the annual financial compensation of damage through e.g. flooding.

4.6.2 Regional Plan Designations with Importance for Carbon or Water Capture and Storage

The proactive mitigation of effects of climate change requires a reduction of carbon release to the atmosphere and a preservation of wet ecosystems and soils. For this purpose regional-specific assessments of the potential of regional plan designations for carbon and water capture will be useful. Succow (2006, 2008b) demanded particularly the remediation and maintenance of the most important sink ecosystems such as moors, lakes, coasts, floodplains and mature woodlands. Table 8 presents an example of an estimation of a range of different plan categories for the mitigation of GHG.

Most plan designations are integrated from sector plans of landscape framework planning, forestry management planning, water management planning or agricultural planning. Their potential for capture and storage of water and carbon will mainly depend on future climatic conditions, soil qualities, water regime and vegetation. This potential will have to be assessed in more detail in the respective sector plans or programmes and at lower planning tiers. For instance the mitigation potential of newly designated afforestation sites will depend on their future function as carbon sinks through carbon forestry, whereby rotation length are increased and the soil is less disturbed. A regional land use plan has the advantage of an overall estimation of the mitigation potential for carbon and water release in a region.

Table 8: Example for estimated mitigation potential of regional plan designations without EIA framework setting with potential positive impacts of capture and storage of carbon and water as well as mitigation of greenhouse gas release (the carbon potential will have to be regional-specifically assessed)

Mitigation Potential of Carbon and Water Capture and Storage	**Regional Plan Designations with Potential Positive Impacts of Capture and Storage of Carbon and Water as well as Mitigation of Greenhouse Gas Release**					
	Designation of areas with the objective of nature and landscape conservation	Designation of securing existent forests	Designation of areas with the objective of soil protection	Designation of areas with the objective of groundwater and water protection	Designation of areas with the objective of local climate protection	Designation of regionally important areas for agricultural production
(5) High International and national importance	Protected nature reserves Protected recreational areas Green corridors, belts	Areas for the securing of forests (particularly native woodlands over 80 years old ≥ 5 ha; semi-natural woodlands with a rotation period of over 60 years)	Green corridors, belts Soils with special functionality Area with potentially high risk of erosion through water Area with potentially high risk of erosion through wind	Protected drinking water catchment areas Area for preventive flood protecttion and further measures for the reduction of the surface runoff New area for future freshwater capture and storage (wetlands and large water reservoirs in no danger to dry out)	Green corridors, belts Cold and fresh air generation areas and corridors New area for the strict protection of cold air generation areas and fresh air corridors against land consumptionfragmentation or pollution	New area for the productive soils of future superior importance in a region to be strictly protected against soil sealing New area for organically or extensively used agricultural land New area for ecological set-aside land
⇨ Derivation of new priority areas for land uses with special importance for mitigation of effects of climate change through carbon and water capture and storage						
(3) Moderate Regional importance and future potential	Areas of the landscape in need of restoration Compensation areas for unavoidable impacts on the natural regime Regional focal areas for woods	Afforestation sites (carbon sequestration after > 60 years with long rotation periods) Protection of mixed forests with >30 % share of broad-leaf tree species;	Soils which are signifycantly impacted in their functionnality and regionally important contaminated sites	Regionally important groundwater sanitation areas Areas of the landscape with special land use requirements for flood water development Surface water in need of restoration: river water sections to be restored, biological quality to be improved	Area for the sanitation of the air and climate	Area for agriculture or viniculture (best practice agricultural use, securing fertile soils against urban settlements) Areas in need of the structuring of the agricultural land
(1) Low Hardly any regional importance or future potential	Anthropogenic cultural landscapes	Intensively used, highly damaged coniferous monocultures	Soil sealed areas of limited possibility of remediation Soil compacted and vegetation-free areas	Areas with an irreversibly depleted water regime	Highly polluted areas Degenerated cold air generation areas	Areas provided for mass breeding installations

4.7 Optimisation of the Regional Plan and Final Decision-Making

An important item for further research, case studies and for practical guidance is the role the SEA-REP assessment results play in the final decision-making process and during the implementation of the REP objectives at lower planning tiers. The highlighting of site-specific environmental conflicts and results of the overall plan assessment have got early-warning functions for the RPB on the future change and development of the environmental state in the region and make the distance-to-target from environmental quality objectives and environmental quality standards transparent. Conflict maps, highlighting the conflict intensity of REP designations with the current state of environmental components and LUCCA, create the basis for the final political decision-making of the RPB. In the future predictions of spatial effects of climate change and the adaptation process at regional level will require special attention in public.

The value of SEA as an instrument of environmental policy depends on how far its results will influence the decision to adopt a regional plan. SEA-REP should not only involve an efficient and transparent process with reliable impact predictions and an appropriate assessment of environmental impacts, but "*should also make sure that the likely environmental impacts of the regional plans will be seen as important factors in each decision*" (Bunge 2005a: 114). This means the process and outcomes of SEA-REP in form of a progressive optimisation of regional planning are important, not the input. An integrated iterative process is crucial in order to save effort and costs and to increase the acceptance of decisions of the regional planners. According to the UK Government (2003) SEA shall improve strategic actions and help decision-makers learn about the environmental impacts of their decisions, information provision and rationalising the process, but it is not able to supply the 'right strategic decision' on an automatic manner. Moreover, the EC SEA Directive does not provide for any substantial legal consequences (Calliess 2005: 56): i.e. the release of a regional plan in form of a decree or ordinance cannot be automatically anticipated, if the SEA-REP has a negative result in terms of a large area classified as 'high conflict' or an adverse development of a region concerning environmental objectives and targets for adaptation to climate change. However, traditional regional plan-making needs to be challenged and dynamically developed as a response to knowledge gain on current and future environmental problems.

4.7.1 Enhancement of Transparency

The aim of an efficient public participation in SEA is to achieve a "*more transparent decision-making and ensuring that the information supplied for the assessment is comprehensive and reliable*" (No. (15) SEA Directive). Participation and involvement at regional level has a high importance, as concerned persons can identify with problems and can learn about consequences of actions (Gustedt et al. 1998: 5). With the integration of the LUCCA indicator system into SEA-REP, the public has the choice to be informed and involved in the setting of future regional development visions and objectives that conflict with the reduction of land degradation and an adaptation of regional land uses to climate change. Therefore the assessment method used and the application of selected indicators and assessment thresholds shall be well documented and understandable. The public can give statements to the regional development in the context of

climate change with the environmental report, which should document all indicators and assessment values of LUCCA and make assessment results, mitigations and draft decisions transparent. The indicators describe and assess currently urgent environmental problems such as regression of biodiversity, loss of highly productive agricultural soils or areas in permanent risk to be flooded, which directly and indirectly affect regional inhabitants and their properties. TransSEA showed, that there is still a need for an improvement and application of processes for public participation and transborder consultation in practice (Stratmann et al. 2007c).

4.7.2 The Environmental Report for Decision Support at Lower Tiers

The result of SEA-REP is the environmental report, which must document the applied assessment method and process. In order to improve political willingness for implementation of adaptation measures in SEA-REP and to raise public awareness, it is crucial that clear and understandable documentation is maintained throughout the conflict assessment process. The SEA report should document unavoidable predictions and assumptions, areas of uncertainty, insufficient information sources, and justifications for decisions. Open communication of determined conflict intensities on specific sites and environmental tendencies in the region, including responding decisions with stakeholders and the public, will improve the acceptance of the regional plan. Stewart (2004: 6) reminded that "good documentation should [also] take account of the potential audience needs", i.e. in this case the regional inhabitants directly affected or concerned by conflicts of REP impacts with adaptation to climate change. At the higher decision-making level of SEA-REP a high need of transparency for concerned parties is foreseen, due to more strategic and abstract contents, in the facing of far-reaching long-term consequences. The environmental report should at least consider five major questions and document information gaps in relation to the regional plan objectives:

- How will regional land uses and resources likely change with effects of global climate change in the future?
- Which conflicts and high risk situations will occur in the region due to vulnerability of areas and land uses to effects of climate change?
- Which mitigation and adaptation measures shall be how and when implemented?
- Which are the main factors that determine the adaptive capacity of land uses and natural resources in the region?
- Which type and location of REP decisions can positively mitigate GHG emissions or environmental pressures and consequently improve the environmental quality of the region?

The SEA-REP environmental report as regional decision-support system for lower planning tiers integrates the assessment of REP impacts with key indicators and assessment thresholds for the integration of climate change into decision-making. An efficient cooperation with landscape framework planning will thus be increasingly advantageous. In the future interdisciplinary expert systems at national and regional level in the EU Member States have to further carry out research on the vulnerability and resilience of LUCCA, taking area-specific effects of climate change into consideration, in order to specify the adaptive capacity of regional land uses. First guidance environmental reports of case studies applying LUCCA will contribute to knowledge on the level of the current vulnerability of the regional state of environment and will assist in formulating future priority action fields. This is important in order to include likely future risks, to prevent from harm of the environment, and to avoid or reduce costs and efforts for the management of natural hazards.

4.7.3 Political Willingness and Sustainable Decision-Making

The final decision, if a certain development shall be planned by a designation in the regional plan and which option is selected, remains a normative decision to be made by the RPB in consultation with stakeholders and under consideration of opinions of the public. The results of SEA-REP do not necessarily improve the status of environmental concerns in regional plan-making, as they may not be considered in the REP weighting process with priority. However SEA-REP contributes to an improvement of the procedural step of the consideration of environmental issues and a higher transparency (Erbguth 2005: 211). The material-legal question, which impacts are to be avoided, depends on a changing societal setting of values in the tension field between socio-economic development and concerns of environmental and nature protection. It is decided in political bodies and in administrative practice on the basis of existent legal requirements, regulations, ordinances and guidelines (Dierßen & Reck 1998: 341). The assessments of each alternative and ranking of reasonable alternatives come to the result of the most appropriate alternative, which is not necessarily the most environmentally-friendly option. The RPB holds the strategic power of coordination of spatial land uses, meaning it prioritises between conflicting goals. The RPB has the competency to decide, which not legally binding environmental aspects from landscape framework planning and sector planning shall be integrated into REP. It is thus finally a political decision how much and which natural and environmental quality the region shall preserve and develop or in simpler words "*what we want and can afford (financially, ecologically and socially) in the future*" (Kiemstedt 1992: 98; see Schwekendiek et al. 1992: 11; Haaren v. 1993: 171). Thus the final decision in SEA-REP should be influenced by the consideration of environmental concerns in the best possible way, but certainly will always be subject to trade-offs (Glasson 1999: 141). In the case of high conflicts without restrictions or medium conflicts the RPB can designate a certain area for a regional development, e.g. a tourism site, as planned, despite conflicting results of the SEA-REP assessment and alternative comparison. If another alternative site with a lower risk classification is available, the RPB has to give very good reasons and justifications for its decisions in the environmental report. These will be justified by an economic demand for this development, which ideally integrates current and future environmental concerns and concerns of climate change as much as is possible.

Higher policy and economic concerns will be of essential importance in final decision-making of the RPB. Costs influence the decision of for instance a withdrawal of environmentally unsound alternatives of REP (Glasson 1999: 142). Effects of climate change on economy will require preventive measures, which reduce costs and effort for disaster management in advance. The adaptation to climate change shall not cause adverse effects on regional societies. The development of lasting solutions therefore requires knowledge about the interactions between the activities of the society and the environmental impacts (NERI 1999).

4.7.4 Need for Post SEA-REP Monitoring

The LUCCA indicators can contribute to the measurement of the percentaged distance between the current environmental situation and the targeted state in a time horizon in the future. Different LUCCA indicators can be compared on their performance with the help of this distance-to-target (Jänicke & Zieschank 2004: 58f). It should be clearly decided, which environmental conflicts

caused by regional development in a respective region will gain special attention and by which means these will be mitigated in the future. Post SEA-REP monitoring as required after Art. 10 of the SEA Directive allows the presentation of development tendencies of sustainable land use in a region within the background of a limited and changing carrying capacity of the environmental components (Walz et al. 1997: 255). The aim is an analysis of whether the assessed importance of each environmental component or LUCCA decreases or increases with the implementation of the regional plan and whether the adaptation process of regional land uses was satisfactorily compared to environmental adaptation objectives. For this purpose a specific monitoring concept for the adaptation of regional land uses to climate change should be developed based on best principles of monitoring (EA2005; EC 2003; Balla 2005; Bunge 2005b). It should allow evaluating physical degradation of LUCCA caused by REP designations and under changed regional climatic conditions. The RPB should not only be able as early as possible detect unforeseen conflicts of REP designations with environmental objectives, but should also be able to correspondingly and efficiently react to these. Contents of a post SEA-REP monitoring system may be:

- the change of the area affected by land consumption in total area and area share;
- the change of the level of the vulnerability and adaptive capacity of LUCCA with experienced effects of climate change;
- the change of the area of LUCCA 1-12 affected by physical degradation (land consumption, land use change, fragmentation, change of water balance, directed flooding) in total area and area share;
- the change of the future area designated as priority area for adaptation to climate change in total area and area share;
- the change of cumulative impacts of REP contents and effects of climate change such as flooding, decreased groundwater level or high air temperatures through land consumption in combination with barriers in air exchange corridors in total area and area share;
- the estimated contribution of the regional plan to the mitigation of greenhouse gas emissions by capture and storage of carbon and water;
- the level of compliance with guiding designations at lower land use planning level;
- the efficiency of mitigation and adaptation measures at project level.

5. LUCCA Indicators

The environmental components LUCCA 1-12 shall gain increasing attention in future planning for land use change, due to their importance for the mitigation of adverse effects of climate change, their potential for carbon and water storage, the possibility of an enhancement of their resilience and carrying capacity, their specific value for adaptation and vulnerability to physical degradation. Derived LUCCA indicators (table 9) are linked to the environmental media and formulated general regional environmental orientation objectives (see table 1), which will have to be specified for a region's current state of environment and its potential to adapt to climate change (adaptive capacity). As it is not possible to assess the regional plan's impact on every receptor, only those resources and land uses that were considered as "*particularly valued by the community or vital to the healthy functioning of the environment*" (CEAA 1999) were selected for LUCCA. Methodologically no range or priorities of LUCCA were defined.

Table 9: State indicators of land uses of importance for adaptation to climate change (LUCCA state indicators)

Land Use of Importance for Adaptation to Climate Change	**LUCCA State Indicators**
Land Uses of Importance for the Protection of Human Health and Air	
LUCCA 1 – Urban areas in risk of heat stress	- settlement areas to be protected against thermal load and supplied with fresh air; - urban residential density in inhabitants per hectare and density of use in soil sealing level; - urban area typologies based on density of population: densely built-up and agglomerated areas, large-scale cities, upper, middle and lower settlements, urban-rural city belts.
LUCCA 2 – Bioclimatic areas with relevance for urban settlements	- open spaces with importance for the bio-climate; - climate protection forests and forests with regional importance for the bio-climate (e.g. forests in the surrounding of cities with > 40 000 inhabitants or agglomerated rural areas); - forested areas with a minimum area size of > 4 ha, which function as fresh air production areas; - cold air flows and air exchange corridors.
LUCCA 3 – Land uses with potential for tranquil recreation in fresh air	- tranquil recreational areas in proximity to urban agglomeration areas; - internationally and nationally legally protected areas according to the national Nature Conservation Act, e.g. in Germany as nature park (zones 1,2), landscape protection area, biosphere reserve (zones 1, 2); - buffer zones of legally protected recreational areas; - regional not legally protected open spaces, which will be suitable for quiet recreation in nature and landscape in the future and are preventively to be preserved against further degradation, noise or pollution increase.

Land Use of Importance for Adaptation to Climate Change	LUCCA State Indicators
LUCCA 4 – Urban areas in risk of flooding	- urban settlements in designated floodplains and retention zones; - urbanised coastal areas below sea water level and potentially from increase of sea level affected urban areas (EC 1998: Annex I, table I.2).
Land Uses of Importance for the Protection of the Structure and Function of Ecosystems	
LUCCA 5 – Areas with potential as refugia or corridor of the ecological wildlife network	- biotope connection areas and elements with transnational, national and regional importance; - land uses with future potential to function as refugia or migration corridors for European, national and regional flagship species; - unfragmented areas.
LUCCA 6 –Forested land	- existent and future public and private forested land, which is harvested for timber according to national forestry management standards, including preservation from soil erosion, loss of native tree vegetation, the capacity of carbon and water capture and storage.
LUCCA 7 – Biotope types with potential for water capture and storage	- biotope types dependent on a high groundwater level; - biotope types with capacity of water (and carbon) capture and storage (managed forests: see LUCCA 6).
Land Uses of Importance for the Protection of the Natural Resources Soil and Water	
LUCCA 8 – Unsealed soils	- unsealed soils of low disturbance; - brownfields with reuse potential.
LUCCA 9 – Soils for high quality agricultural food production	- productive soils, assessed in soil figure for arable land and grassland (including an estimated future potential and need for irrigation, pesticides and fertilizers and the intensity of management).
LUCCA 10 – Soils to be protected against erosion	- arable areas with requirements for protection against water erosion (after fine soil types of the topsoil) according to the potential of erosion through water expressed in water erosion resistance; - arable areas with requirements for protection against wind erosion according to the potential of erosion through wind expressed in wind erosion resistance.
LUCCA 11 – Freshwater resources with long-term potential for water storage and supply	- regional water bodies with future potential for water storage and supply under spatial effects of climate change (first and second category waters); - land uses with future potential of groundwater development; - land uses with future potential of a remediation of the water regime (third category waters).
LUCCA 12 – Land uses with potential for retention and absorption of precipitation and inundation water	- designated floodplains and retention zones; - natural river sections (water quality I-II); - absorption capacity of water bodies and reservoirs; - evaporation and transpiration rates of land uses; - retention ability of land uses.

The choice of the state indicators for LUCCA was undertaken in an independent approach from necessary regional data, but instead based on regional environmental orientation objectives for the adaptation to climate change, i.e. desired end-states. The list of state indicators is not exhaustive. The LUCCA state indicator system is not understood as a blueprint indicator system, but serves as a driving force for the federal and regional planning authorities to operationalise more specific and strict regional environmental objectives, as well as to derive assessment thresholds for adaptation of a specific region to climate change. Not all LUCCA indicators are always relevant, transferable or applicable in their current form in a European region. A competent authority should continuously revise the indicator system before and after its first application in practice, in order to identify additional state indicators and improve the proposed state indicators, which must be measurable with adequate environmental data. The eligibility of each LUCCA has to be revised in the light of baseline data, a direct link of the deriving state indicators and impact indicators to the REP objectives, and any methodological deficiencies and data gaps identified. Each LUCCA should create an effective link between at least one impact of a REP designation, adverse effect of climate change and their site-specific implementation and effects. State indicators, which turn out in practice to be inadequate for the regional land use planning level, should be tiered down to land use planning in the SEA-REP process.

5.1 Structure and Environmental Data Needs

In the following, LUCCA 1-12 are presented in separate sections of the thesis. During a SEA-REP process every effort should be made to deal with the environment in a holistic and comprehensive way, which integrates all relevant aspects for an adaptation of land use and resources to climate change, and to recognise the complex inter-relationships that exist between environmental components and different impact factors beyond physical degradation alone.

Information on LUCCA was systematically structured with:

- definition;
- regional environmental orientation objectives;
- derivation of environmental state and impact indicators;
- environmental data requirements;
- assessment thresholds and their methodological derivation;
- classification of the environmental conflict intensity; and
- proposals for tiering, mitigation and adaptation measures.

Necessary environmental data was described in a generalised way. For an effective application of the LUCCA state indicators, assessment thresholds will have to be regionalised on the basis of spatial area-specific data. This will have to integrate regional-specific forecasts for effects of climate change.

5.2 Indicators for Land Uses of Importance for the Protection of Human Health and Air

In sustainable regional planning special emphasis is put on the living space in rural and urban settlements. As a principle of German spatial planning, the protection of the population against noise and air pollution must be secured (Art. 2 ROG). Population and human health are interrelated with the quality and quantity of all other environmental media. In an anthropocentric approach humans can only lead a healthy life and achieve a high living standard, if the environmental quality of land and resources in general is high. This particularly includes fresh air, drinking water and food security. The sensitivity and importance of an area for human health and well-being can be classified according to Schmidt C. et al. (2004) into the living function and the recreation function. The supply of urban areas with fresh air depends on the preservation and improvement of cold air generation areas and fresh air corridors, which are threatened by land consumption, land use change or fragmentation. Land uses of importance for these two functions will have to be adapted to climate change. Particularly cumulative and synergic impacts of regional plan designations in combination with effects of climate change (e.g. land consumption combined with increasing air temperatures and aridity), will endanger human health. Initiatives to safeguard and improve the human living and recreation function in the frame of annually average increasing summer temperatures and heat waves were integrated into SEA-REP through the following LUCCA 1-3.

5.2.1 LUCCA 1 – Urban Areas in Risk of Heat Stress

Urban areas will be affected in the future by increasing average temperatures in winter and summer, which will have positive and negative effects on mortality and human health (see chap. 3.3.3). An objective of regional planning is to prevent industrial development on green fields or open spaces in urban areas in high risk of heat stress (SMUR 1997: 5, 7). The urban quality of life of the inhabitants and the local climate are directly linked to settlement density, structure and housing typologies, urban energy and accessibility of public transportation systems (Storch 2007: 837; Flacke 2003; Apel et al. 2000). An efficient use of land requires an operationalisation of targets for minimum urban densities and a stricter protection of the rural landscape in the outskirts of cities as well as open spaces against land consumption. Currently regional plan designations of new urban settlements in suburban areas are determined on the level of municipalities in a demand-driven approach, which takes demographic change and sustainable criteria for site selection (e.g. brownfield development, link to public transportation infrastructure) and the quantification of housing demand into consideration. In the future regional planning should contribute to a stricter framework at higher scale for the prevention of heat stress and the increase of the urban living quality by remediation of dense suburban areas.

Definition

This indicator measures the potential conflict of future land consumption on open spaces and in the periphery of urban areas of different densities of land use in the municipalities of a region. Additional land consumption changes the local climate and adds to increasing urban summer temperatures and heat stress supported by climate change.

Regional Environmental Orientation Objective

- prevented and remediated housing and industrial development on green fields in urban areas in high risk of heat stress;
- reduced soil sealed area share in urban areas;
- established regionalised framework for minimum housing densities;
- safeguarded green and open spaces in the inner city and periphery;
- improved accessibility of infrastructure, public transport and recreational areas.

Derivation of Environmental State and Impact Indicators

State indicators:

- settlement areas to be protected against thermal load and supplied with fresh air;
- urban residential density in inhabitants per hectare and density of use in soil sealing level;
- urban area typologies based on density of population: densely built-up and agglomerated areas, large-scale cities, upper, middle and lower settlements, urban-rural city belts.

Impact indicators:

- land consumption in urban areas with special, general and inferior importance of the risk of heat stress on the affected area in hectares (ha).

Environmental Data Requirements

- climatic maps with urban areas with climate function with potential for ventilation and risks of heat zones;
- vulnerability maps;
- built environment: urban structures and area share of open spaces etc.;
- unused brownfields and their reuse potential for housing or recreation.

Assessment Thresholds and their Methodological Derivation

The RPB should create a guidance of minimum housing area densities for the lower binding land use planning (table 10) (PGW 2002; Weick 2003). These regionally calculated guidance values for the designation of new building sites of the municipalities are based on the central place system, city edges and population forecasts of conventional regional planning (Happe et al. 1999). The methodological process of the derivation of these guidance values for the designation of building sites and their compliance can be assessed in the overall strategic plan assessment as part of SEA-REP. The proposed classification of urban densities uses upper, middle and lower centres of the central place system as a basis, as these are also linked to certain standards of supply and infrastructure. Thresholds for residential densities were derived from the orientation values for gross housing density in different types of German settlements (Stiens & Pick 1998; Happe et al. 1999: 83). Quality standards for public green spaces were for instance defined by Wickop et al. (1998: 105ff) for Leipzig with > 3 m² per inhabitant for connected housing types, and with > 6 m² per inhabitant for open housing types. In Berlin the minimum area share of near-residential open spaces covers minimum area sizes of > 0,5 hectares in an intake area of 500 m (Senatsverwaltung für Stadtentwicklung Berlin 2008).

Table 10: Orientation values for housing densities and soil sealing levels

(Source: Happe et al. 1999: 83)

Type of settlement/location		Orientation values	
		Gross housing density*	Soil sealing level
Metropolis/upper centres/ agglomerations (> 100 000 inhabitants)	Central areas	280-350 inhabitants/ha	60-80 %
	Locations at city edge	210-320 inhabitants/ha	50-70 %
	Locations at town edge	140-210 inhabitants/ha	40-60 %
Middle centres/ agglomeration edge zones (> 20 000 inhabitants)	Central areas	210-350 inhabitants/ha	50-70 %
	Locations at city edge	140-280 inhabitants/ha	40-70 %
	Locations at town edge	80-200 inhabitants/ha	30-50 %
Lower centres/rural areas (> 10 000 inhabitants)	Central areas	180-250 inhabitants/ha	40-65 %
	Settlement edge locations	50-180 inhabitants/ha	25-60 %
*net housing density x 0,7/deduction for transport and green spaces			

Quantitative values given in table 11 will have to be operationalised for a specific region and modified with spatial knowledge on the dependencies of urban land uses and air temperature increase. The final decision on urban settlements should consider the safeguarding of bio-climatic areas with relevance for human settlements and land uses with potential for tranquil recreation in fresh air in agglomeration areas and their periphery (see LUCCA 2 and 3, chaps. 5.2.2 and 5.2.3).

Table 11: Estimated risk of heat stress of urban areas based on their residential density and density of use

(5) Special Importance	Very densely populated urban areas of high vulnerability to heat stress: Metropolis/upper centres/agglomerations with - > 100 000 inhabitants; - > 200 inhabitants/ha; - < 3 m² open space per inhabitant (guidance threshold for Leipzig); - soils > 70 % sealed; - low area share of green spaces
(3) General Importance	Densely populated urban areas of medium vulnerability to heat stress: Middle centres/agglomeration edge zones with - > 20 000 inhabitants; - 3-6 m² open space per inhabitant (guidance threshold for Leipzig); - soils 50-70 % sealed; - medium area share of green spaces
(1) Inferior Importance	Sparsely populated urban areas of low vulnerability to heat stress: Lower centres/rural areas with - > 10 000 inhabitants; - > 6 m² open space per inhabitant (guidance threshold for Leipzig); - soils < 50 % sealed; - high area share of green spaces - rural settlements with a high variety of the landscape character; - open green spaces and parks, regional green corridors and green belts;

Classification of the Environmental Conflict Intensity

A proposal for a classification of the environmental conflict intensity of heat stress promoted by new soil sealing in urban peripheries is presented in table 12. Urban development is a complex task, which was recognised in the last years to require more attention, because of the irreversible loss of soils. LUCCA 1 is mostly interrelated with other LUCCA: the environmental conflict analysis for SEA-REP includes an evaluation of the best practice preservation of unsealed soils (LUCCA 8), agricultural soils (LUCCA 9), bioclimatic areas with relevance for human settlements (LUCCA 2) and land uses with potential for tranquil recreation in fresh air (LUCCA 3) in a region.

Table 12: Conflict intensity of LUCCA 1

Assessment of the environmental impacts on the individually affected area (5) = Special importance, (3) = General importance, (1) = Inferior importance	
Conflict Intensity	**Effect of impact factors/impact indicators on the affected area with importance according to the assessment of the environment**
	Land Consumption
1. High Conflict	5
2. Medium Conflict	3
3. Low Conflict	1* *with adequate preservation of unsealed soils (LUCCA 8), agricultural soils (LUCCA 9), bioclimatic areas with relevance for human settlements (LUCCA 2) and land uses with potential for tranquil recreation in fresh air (LUCCA 3).
Positive Environmental Impacts	Assessment in comparison of alternatives of site-specific REP contents: Designations of urban settlement on brownfields in urban areas of low vulnerability to heat stress (case-by-case analysis)
Mitigation and Adaptation Measures	Designation of priority areas for green spaces and green corridors Designation of priority areas for desealing and remediation to open green spaces
Tiering	More detailed case-by-case assessments of the vulnerability of urban areas and their housing typologies to climate change have to be carried out at lower urban planning level. These include indicators for the variety of uses in neighbourhoods, the central function of agglomeration centres and the accessibility of public transportation infrastructures.

Interim targets for the prevention and mitigation of heat stress in urban agglomeration areas involve action based on vulnerability assessments such as the implementation of minimum standards for area shares of open and green spaces and a target-oriented desealing and remediation of areas with potential for cold air generation or as fresh air corridor. Regional planning should define clear benchmarks for actions in close cooperation with climatologists and landscape planners. Socio-economic scenarios of urban development through risk mapping of populations and assets to assess vulnerability and exposure will have to be well linked to the environmental conflict analysis (UNFCCC 2007).

5.2.2 LUCCA 2 – Bio-climatic Areas with Relevance for Human Settlements

Higher future air temperatures of climate change will affect human health negatively and will require an improved bio-climatic system especially for urban areas of high density. The bio-climate is defined as the sum of all factors of the climate affecting living organisms. It is influenced by the global climate and its alterations. The bio-climate is currently integrated into regional land use planning through designated areas for fresh air and cold air generation or corridors for air exchange. The atmospheric conditions of the environment including the temperature equalisation and ventilation, influence the human well-being, productivity and health in a region.

Definition

LUCCA 12 consists of bio-climatic areas that are of importance for the regeneration of fresh and cold air with relevance for human settlements. These are for instance climate protection forests or areas with local climatic functions of fresh and cold air generation, air outflow or exchange. Further land uses are considered, which are particularly sensitive against barriers of (highly polluted) air at a local scale such as river basins and valleys.

Regional Environmental Orientation Objectives

- safeguarded fresh air supply of initially highly polluted settlement areas from fresh air generation areas over air exchange corridors;
- preserved areas of importance for the bio-climate and air hygiene against any degradation;
- maintained and improved open spaces in accessibility of agglomeration areas;
- safeguarded and improved flow and exchange of fresh and cold air, ensuring that urban populations can cope with air temperature extremes;
- prevented new barriers and removed former barriers to air exchange;
- protected and extended compact forests, particularly those sustainably managed, in the outskirts of urban agglomeration areas.

Derivation of Environmental State and Impact Indicators

State indicators:

- open spaces with importance for the bio-climate;
- climate protection forests and forests with regional importance for the bio-climate (e.g. forests in the surrounding of cities with > 40 000 inhabitants or agglomerated rural areas);
- forested areas with a minimum area size of > 4 ha, which function as fresh air production areas;
- cold air flows and air exchange corridors.

Impact indicators:

- land consumption on areas of special, general and inferior importance for the bio-climate in ha;
- land use change on areas of special, general and inferior importance for the bio-climate in ha;
- barrier effect for areas of special, general and inferior importance for the bio-climate.

Environmental Data Requirements

- bio-climatic models will have to be analysed on their applicability in regional planning;

- dynamic bio-climatic maps considering current meteorological data, short-term forecast data and future climate scenarios, normal and extreme weather situations in different urban structures;
- existing bio-climatic maps are static and show only chosen situations under average summer conditions;
- green- and open space inventory.

Assessment Thresholds and their Methodological Derivation

Continuous surveys and assessments of areas with high current and predicted future potential for fresh and cold air should be carried out by landscape planners in order to develop dynamic maps and deliver assessment thresholds for SEA-REP. In Germany a conventional objective of landscape framework planning (LRP) for the protection of air and climate is to deliver objectives for air circulation, air exchange, inversion, climatic conditions and the filter function of vegetation units for:

- cold air generation areas;
- fresh air generation areas;
- air exchange corridors;

and to deliver strategies to prevent from and mitigate:

- air hygienic pollutions;
- human-induced thermal loads of the air;
- barriers to cold air flow and interruptions of air circulation.

Priority areas for the protection of the local air and climate are integrated into the regional plan.

With the aim of adaptation to climate change in a first step the assessment of existent and potential cold air generation areas and fresh air corridors (including their initial pollution level) in the region should be amended for the peripheries of urban agglomeration areas of high density. A stricter focus in the future will have to be put on the vulnerability, resilience and environmental potential of forests and other climatologically important areas for the safeguarding of fresh and cold air supply of urban areas, and accordingly on the priority to be strictly protected against land consumption, land use change and barrier effects.

According to Burschel & Huss (1987: 32ff) in central Europe an interior forest climate evolves above an area size of four hectares. In the future the provision of large-scale cities with fresh air during summer heat waves will likely require large-scale unfragmented forested and open areas, which are evenly distributed at the borders of a city. Table 13 shows a possible classification of the current importance of land uses for the bio-climate for Saxony, which will have to be specified with consideration of regional data on effects of climate change.

Table 13: Assessment of the importance of bio-climatic and open areas for the supply of humans in the periphery of cities and agglomeration areas with fresh and cold air

(5) Special Importance:	Bio-climatic and open spaces with a high need to be protected against degradation/barriers: Climate protection forests; Forests with a regional importance for climate protection in the periphery of cities and agglomeration areas; Important cold flows and air exchange corridors; Cold air generation areas in the catchments of larger heavily polluted areas (assessed according to criteria in the environmental objectives); Open spaces in the periphery with a high need to be preserved against degradation/barriers.
(3) General Importance:	Bio-climatic and open spaces with a medium need to be protected against degradation/barriers: Connected forest areas with area sizes of > 4 ha* with relevance for the climate in urban settlements (fresh air generation areas); Open spaces in the periphery with a medium need to be preserved against degradation/barriers; Forests with an area size < 4 ha with relevance for global climate protection.
(1) Inferior Importance:	Bio-climatic and open spaces with a low need to be protected against degradation/barriers: Forests with an area size < 4 ha without relevance for the global or bio-climate; Open spaces in the periphery with no or a low need to be preserved against degradation/barriers.
*forests with sizes > 40 ha are covered by the assessment of unfragmented areas in LUCCA 5)	

Qualitative assessment criteria of the sector contribution of nature conservation and landscape maintenance (LRP) of OL-NS (LRP chap. 1.4-1, SMI 2003b) for the safeguarding of large-scale fresh air and cold air generation areas on not built-up, open spaces are:

- a cold air outflow of > 100 m³/s;
- no important emitters in the closer surrounding (in a distance of > 500 m);
- no heavily used roads (< 10 000 motor vehicle/day);
- an initial pollution level of < 25.0 µg NO_2/m³;
- good conditions of the air ventilation close to the surface (medium wind speed of over 3.0 m/s, frequency of inversion less than 220 days annually).

The safeguarding and optimisation of regionally and sub-regionally important cold and fresh air flows as compensation areas for the air exchange is based on the following criteria:

- unsealed areas with high coarseness of the surface finish (< 0.5 m);
- land use change with the aim to increase the permeability of the soil (e.g. desealing as compensation measure);
- minimum width of 300 m;
- air flow section without barriers;
- adjustment towards the area of influence.

Part of the assessment should also be the predicted thermal load of different land uses in summer (see table 14). For instance Henz (1998) assessed the current thermal load on the basis of a satellite image showing summer radiation temperatures of surfaces, which can be distributed to specific land use structures. As the average summer air temperatures and radiation intensity will increase with climate change, a revision of proposed thresholds and efficient monitoring of the thermal load of land uses will be necessary.

Table 14: Assessment of the thermal load of land uses

(Sources: Henz 1998; RPV Mittlerer Oberrhein 2003, 2005).

(5) Special Importance:	<u>High thermal load:</u> Climate protection forest, immission protection forest, cold air streams with bio-climatic functions (RPV Mittlerer Oberrhein 2003, 2005); Connected meadows; mixture of meadows, woodland, hedgerows, shrubs; connected orchards > 5 ha; Interior forest edges with average water supply with diameter of 500-1000 m; Dry forests >1 km diameter; Connected wet grasslands; water bodies; Floodplain forest > 500 m diameter; Interior of forests without edges > 1 km diameter with average water supply.
(3) General Importance:	<u>Moderate thermal load:</u> smaller forests without air hygienic effects, cold air production sites with bio-climatic exchange function; (RPV Mittlerer Oberrhein 2003, 2005); Large-scale arable land; mixture of arable land and meadows; dry or poor grasslands; horticultural land; gardens; hedgerows, shrubs; orchards; parks and other open green spaces.
(1) Inferior Importance:	<u>Low thermal load:</u> no climate and protection forest (RPV Mittlerer Oberrhein 2003, 2005); Sealed soils > 50 %.

Open spaces in particular danger of land consumption are green corridors and green belts. Consequently Scholles (1990) proposed setting a minimum standard for the protection of the area share of open spaces in municipalities of agglomeration areas of for instance > 50 %. A regional plan should create a framework for the general safeguarding of green corridors and belts linked to case-by-case assessments at lower binding land use planning level. Predicted effects of climate change demand stricter adaptation areas and compensation areas, which are to be desealed and remediated to green spaces within the borders of a city or in its outskirts. Additional guidance could be given for the raising of the quality of existing settlement, e.g. by improving residential areas, so that no need arises for new land development. This not only contributes to the conservation of soil and habitats but also reduces traffic volumes and the fragmentation of landscapes (BMU 2007a).

Classification of the Environmental Conflict Intensity

Land uses with importance for cold air generation and fresh air exchange are used to derive conflict intensities for SEA-REP (table 15). The classification of barrier effects requires specific qualitative case-by-case decisions. Existent data bases on the thermal load particularly in highly soil sealed or not vegetated areas will have to be revised with climate scenarios.

Table 15: Conflict intensity of LUCCA 2

Assessment of the environmental impacts on the individually affected area (5) = Special importance, (3) = General importance, (1) = Inferior importance			
Conflict Intensity	**Effect of impact factors/impact indicators on the affected area with importance according to the assessment of the environment**		
	Land Consumption	**Land Use Change**	**Barrier Effect**
1. High Conflict	5	5	5
2. Moderate Conflict	3	(5*)/3	3
3. Low Conflict	1	1	1
	*If no deforestation is expected.		
Positive Environmental Impacts	Assessment in comparison of alternatives of site-specific REP contents: Afforestation of areas in the outskirts of agglomeration areas and cities, which shall function as air generation sites, according to objectives of sustainable forest management (integration from forestry sector; see LUCCA 5).		
Mitigation and adaptation Measures	Designation of land uses and open areas with high importance for fresh and cold air generation and exchange with relevance for urban and agglomeration areas with the objective to provide clean and fresh air for the people living in an agglomeration area, to safeguard climatically important fresh and cold air flow corridors and to prevent from barriers to air exchange. Integration of regionally important cold air generation areas into regional corridors, and regionally important fresh air generation areas into reserve and priority areas for the protection of existent forests.		
Tiering	More detailed assessments on the cooling function of biotope types under climate scenarios; Specification of climatic conditions and measures.		

An example for a proposed interim target, to be area-wide achieved by for instance the year 2020, is an area-wide revision of assessments of biotope types, forests and open areas on the basis of their importance for fresh and cold air production and exchange with relevance for urban and agglomeration areas. Areas of high future importance under effects of climate change should be designated in regional land use plans as priority areas for the protection of the bio-climate.

5.2.3 LUCCA 3 – Land Uses with Potential for Tranquil Recreation in Fresh Air

Climate change will lead to an increasing demand of urban populations for open areas. Particularly in highly populated cities and urban agglomerations more people will require adequate areas for recreation in quietness and fresh air, which can be accessed within short travel times (Troge & Hutter 2004). Open spaces in proximity of agglomeration areas and a decentralised settlement structure have to be preserved and improved (SMUR 1997: 5, 7; CCW et al. 2004b: 6).

Definition

LUCCA 3 describes land uses, which have the potential to provide a recreational function under temperature and radiation increase. Recreational areas should be ideally suitable for multi-functional uses; of high value are vegetated areas, which provide fresh air, natural silence, shelter and shadow.

Regional Environmental Orientation Objectives

- safeguarded recreational areas in adequate density in proximity of urban agglomeration areas;
- protected particularly quiet recreational areas of high landscape value;
- decentralised settlement structure;
- concentrated settlement growth largely on the network of spatial central places and on development axes.

Derivation of Environmental State and Impact Indicators

State indicators:

- tranquil recreational areas in proximity to urban agglomeration areas;
- internationally and nationally legally protected areas according to the national Nature Conservation Act, e.g. in Germany as nature park (zones 1 and 2), landscape protection area and biosphere reserve (zones 1 und 2);
- buffer zones of legally protected recreational areas;
- regional not legally protected open spaces, which will be suitable for quiet recreation in nature and landscape in the future and are preventively to be preserved against further degradation, noise or pollution increase.

Impact indicators:

- land consumption of restricted areas or open spaces with special, general and inferior importance for tranquil recreation in fresh air in km² or ha;
- land use change of restricted areas or open spaces with special, general and inferior importance for tranquil recreation in fresh air in km² or ha;
- fragmentation of restricted areas or open spaces with special, general and inferior importance for tranquil recreation in fresh air in km and rest area share;
- directed flooding of restricted areas or open spaces with special, general and inferior importance for tranquil recreation in fresh air in km² or ha.

Fragmentation by transport or energy supply infrastructure potentially leads to smaller area shares with an increased potential for noise whilst the directed flooding of recreational spaces, e.g. in

floodplains, likely narrows their multi-functional use for the population. Site-specific decisions on the purpose and function of floodplains in the context of the geographic environment are required.

Environmental Data Requirements

- recreational value, vulnerability of recreational and open areas accessible from urban areas;
- open space inventories.

Assessment Thresholds and their Methodological Derivation

Criteria relevant for the determination of these areas are their:

i) Current protection status: internationally and nationally protected recreational areas for a quiet recreation in the landscape, such as German nature parks (zones 1 and 2), landscape protection areas, and biosphere reserves (zones 1 and 2).

ii) Suitability for tranquil recreation in fresh cool air: other unprotected open spaces and tranquil zones of relevance, which are suitable for quiet recreation in nature and landscape and shall be protected against noise and pollution increase such as recreation forests. The suitability shall include compensation areas for temporarily flooded parts and parts that function as shelter against wind and high temperatures.

iii) Maximum distance to settlement areas: adequate open spaces and recreational areas should be accessible from the main urban areas in a region. They include urban open spaces within the borders of a city. Areas without the borders of a city shall be located in a reasonable travel distance to central places and higher and middle centres.

In a first step a revised assessment of the suitability of biotope types and land uses for recreation and their adaptive capacity with the parameter of their future state of environmental quality, initial noise and pollution level and accessibility should be carried out (see table 16).

Current predictions of effects of climate change shall be considered for the assumption of the future potential of the areas to provide space for recreation under increased heat and radiation. More specific data on interrelations between land uses suitable for human recreation and health issues influenced by effects by climate change will be necessary, in order to create a regional framework for the designation and development of 'secure' areas for leisure and sport.

As an instrument to protect open spaces existent green corridors and green belts in agglomeration areas will gain importance in the context of higher temperatures, heat waves and aridity resulting from climate change. Green corridors protect larger connected open spaces against settlements; they prohibit suburbanisation processes, where two settlements tend to grow together, and therefore take over an essential function of connecting multifunctional spaces (Domhardt 2005). They can also link to or overlap fresh air corridors and cold air production areas in the outskirts of urban areas. Therefore green corridors are essential REP designations for the mitigation of adverse effects of climate change.

Table 16: Assessment of the suitability of biotope types and land uses for recreation

(Source: modified from PÖU et al. 1993)

(5) Special Importance:	<u>High suitability:</u> - buffer zones of legally protected recreational areas; - semi-natural or extensively used woodland and shrubs, grass- and heathland, wetlands and moors, orchards, tree alleys; - semi-natural sources, rivers including their floodplains and lakes; - semi-natural forests; gardens or cemeteries rich in old trees and natural structures; open green spaces and parks; - rural settlements with a high variety of the landscape character and rich in trees - recreation forests assessed according to forest function map; - regional green corridors and green belts.
(3) General Importance:	<u>Moderate suitability:</u> - species-poor intensively used grassland; - cleared open countryside; - fallow land; - strongly anthropogenic influenced sources, rivers and lakes; - allotments; urban areas with high share of trees; cemeteries.
(1) Inferior Importance:	<u>Low suitability:</u> - intensively used arable and horticultural land; - densely populated urban areas; - soils > 50 % sealed; - mining, industrial and commercial sites; contaminated sites - military areas; - Infill sites.

The suitability of open areas for recreation in the future will to a great extent be influenced by the initial noise and pollution level. Jain et al. (2001: 138) brought to the point that „noise is one of the most pervasive environmental problems“. They found that the area of noise exposure increases as a function of population growth, population density, mobility and industrial activities. Especially affected by noise nuisance are humans in urban settlements and exposed open areas. Particularly quiet recreational areas have to be protected against physical degradation (see table 17). An assessment parameter is the initial noise level at daytime in open spaces suitable for recreation. Area-wide noise levels of the national strategic noise maps, to be implemented with the EC Noise Directive 2002/49/EC, will have to be regionalised. Minimum distances of recreational areas to noise and pollution sources and mitigating buffer zones will also have to be applied in SEA-REP.

Table 17: Assessment of the initial noise level of recreational sites

(Sources: Federal transport plan (BVWP); LfU B-W 1995: chapter 4.1; Kaule 2002, Tab. 9.5.)

(5) Special Importance:	<u>Low initial noise level:</u> - < 40 dB(A) at daytime: very low noise level; - 40-50 dB(A) at daytime: low noise level; - distance from country road (< 10 000 vehicles/day) > 800 m; - distance from federal road (25 000 vehicles/day) > 1 500 m; - distance from motorway (≥ 50 000 vehicles/day) > 3 000 m.

(3) General Importance:	Moderate initial noise level: - 50-65 dB(A): moderate noise level; - distance from country road (< 10 000 vehicles/day) 200-800 m; - distance from federal road (25 000 vehicles/day) 400-1 500 m; - distance from motorway (≥ 50 000 vehicles/day) 800-3000 m.
(1) Inferior Importance:	High initial noise level: - > 65 dB (A) at daytime: high noise level; - distance from country road (< 10 000 vehicles/day) < 200 m; - distance from federal road (25 000 vehicles/day) < 400 m; - distance from motorway (≥ 50 000 vehicles/day) < 800 m.

Currently partly regional data is available on the pollution level in open spaces. National data on initial air pollution levels will soon be available with the implementation of the EC Directive on national emission ceilings for certain pollutants (NEC Directive 2001/81/EC), which should be then operationalised for an application in SEA-REP (table 18). The distance to the exceedance of air quality standards can be estimated and then serve as criteria for the assessment of the importance of areas suitable for recreation.

Table 18: Assessment of initial pollution level of recreational sites

(5) Special Importance:	Low initial pollution level: - recreational spaces with low air pollution level or sensitive to air pollution; - recreational spaces with low pollution levels below air standards; - (> 50 % from exceedance of air standards).
(3) General Importance:	Moderate initial pollution level: - recreational spaces with moderate pollution levels below air standards; - (25-50 % from exceedance of air standards).
(1) Inferior Importance:	High initial pollution level: - recreational spaces insensitive to air pollution; - recreational spaces with high pollution levels just below air standards; - (10-25 % from exceedance of air standards).

A minimum area size of > 0,5 km² is adequate for open areas with importance for recreation as part of LUCCA 3 in SEA-REP. Smaller open areas are tiered down to SEA of binding land use planning. The travel distance to accessible recreational areas is ideally less than 4 km from urban areas and public transport (EC 1998: Annex I table I.2). Recreational areas are then accessible within less than half an hour travelling time. The travel distance from urban centres to recreational areas has got an impact on human health and potential energy consumption of transport and thus GHG emissions originating from traffic. The accessibility of areas without too long journeys and barriers is important for one-day recreation and leisure and should thus be integrated into SEA-REP. Table 19 presents possible quantitative values for a preventive framework at Saxon regional plan level, which have to be regionalised based on the regional density of open spaces and their quality for a multi-functional recreational use.

Table 19: Assessment of the distance of recreational sites from middle centres, upper centres, agglomeration areas and public transport

(5) Special Importance:	Recreational spaces suitable for quiet recreation in fresh air in a distance of < 6 km (Saxony).
(3) General Importance:	Recreational spaces suitable for quiet recreation in fresh air in a distance of 6 to 10 km (Saxony).
(1) Inferior Importance:	Recreational spaces suitable for quiet recreation in fresh air in a distance of > 10 km (Saxony).

In Saxony the recreation pressure from dense agglomeration areas on the immediately bordering local recreational areas in a distance of up to a perimeter of approximately 6 km is significant (SMI 2003b: 20). A perimeter of 6 to 10 km from the central point of the urban centres was used in OL-NS for the assessment of the distance of recreational areas (Stratmann et al. 2007a). Other guidance thresholds from Germany (LEP I of Brandenburg) for the accessibility of centres of the German system of central places with public transport system are: lower centres 30 min, middle centres 60 min and upper centres 90 min (Stiens & Pieck 1998: 421).

Classification of the Environmental Conflict Intensity

The individual results of the assessment of the above parameters create a framework for regional site-specific decisions of alternative designations and will have to be operationalised (see table 20).

Table 20: Conflict intensity of LUCCA 3

Assessment of the environmental impacts on the individually affected area and impact zone (5) = Special importance, (3) = General importance, (1) = Inferior importance				
Conflict Intensity	**Effect of impact factors/impact indicators on the affected area with importance according to the assessment of the environment**			
	Land Consumption	**Land Use Change**	**Fragmentation**	**Directed flooding**
1. High Conflict	5, 3	5	5	–
2. Medium Conflict	1	3	3	5, 3
3. Low Conflict	–	1	1	1
Positive Environmental Impacts	Assessment in comparison of alternatives of site-specific REP contents: Designation of former mining pit as water body for recreational use; Designation of afforestation site.			
Adaptation Measures	Designation of priority areas of sufficient quantity and quality for multi-functional recreation in open spaces and recreational areas on the basis of their suitability and location. These priority areas shall be accessible and located in proximity of urban areas Designation of priority areas of green corridors Created framework for a minimum area share of open spaces in the urban			

	periphery in relation to the number of inhabitants per square metre, urban building densities, types of housing and accessibility to public transport systems; Avoided conflicting area designations through overlap of priority areas for the preservation of existent forest or priority areas for recreation with planned regional developments leading to a loss of these land uses (e.g. reserve areas for mining or reserve areas for urban or industrial development).
Tiering	Specification of potential of recreational sites under climate change conditions at lower tiers; No conflicting designations of reserve areas in open spaces in proximity of urban centres; Compliance to minimum distances to land uses with anticipated impacts of noise and pollution; Case-by-case decisions on urban developments on open areas; Case-by-case decisions on directed flooding of former floodplains, which are used as recreational areas.

An interim target should be set for the development of a future regional framework conception for a large-scale open space system, which shall serve the preservation of areas for tranquil recreation in fresh air under changed global climate conditions. Focus areas shall be better connected and less attractive and structurally poor spaces of the region shall be integrated into the open space system over existent or new landscape structures, with the aim to provide an improved connection to lower centre settlements and achieve sustainable open spatial planning (MKRO 1997). Priority areas of land uses with future potential as recreational areas shall be identified and integrated into regional planning. The task of German landscape framework planning in cooperation with forestry and water management is a future-oriented coordination of different multi-functional open spaces. Spatially-relevant concepts shall also be subject to the overall strategic assessment of the regional plan.

5.2.4 LUCCA 4 – Urban Areas in Risk of Flooding

Urban areas in floodplains are increasingly endangered of flooding, as floodplains originally serve the discharge and retention of floodwater. With a scenario of rising sea levels by up to two metres, low coastal land below sea water level also will be inundated, unless sufficiently dimensioned technical sea defences can be raised (WBGU 2006; EA 2006c) As there is a limit to technical mitigation measures planning for land use change intents to prevent populations in coastal areas from harm by the implementation of new strategies for coastal protection. Adaptation of land uses in coastal areas below sea water level is integrated into SEA-REP to avoid designations such as industrial sites in areas below sea water level. A strict regional adaptation framework may involve the banning of any new building close to sea level or in the accessibility of tidal storms (Cairncross 2006: 31).

A regional framework for adaptation will minimise future risks for humans and costs of loss and damage of material assets. Regional designations for protecting and managing coastal land use need to consider predicted effects of higher water levels and more intensive storm tides. WBGU (2006) calls for portfolio strategies, which combine and weight methods of protection, managed

retreat and accommodation. They also recommend a better link between coastal protection and nature conservation concerns and the involvement of the people affected by adaptation or resettlement measures in decision-making on such measures. A strategic approach to coastal planning and management as defined in the Integrated Coastal Zone Management (ICZM) integrating future scenarios of climate change is required (EC 2006).

Definition

LUCCA 4 describes urbanised areas, which are vulnerable to floods, because they are lying in floodplains or below a predicted sea water level of one metre above pre-industrial times. In the case technical flood prevention measures do not exist or fail, these areas will be temporarily or permanently lost to sea, or more frequently and intensively flooded in the future.

Regional Environmental Orientation Objective

WBGU (2006: 2, 6, 40, 49) recommends that the absolute sea-level rise should not exceed one metre from the pre-industrial level in the long term, and the rate of rise should remain below five centimetres per decade at all times, so that the adaptive capacity of coastal societies will not be overstretched. Otherwise a high probability is predicted that human society and natural ecosystems will suffer unacceptable damage and loss. Further objectives are:

- state-of-the-art knowledge on effects of climate change on river flows and sea level rise taken into account in infrastructure design in coastal areas (EC 2007a: 19);
- decreased risk of flooding of urban areas below sea water level through protection and accommodation;
- managed retreat of urban settlements from endangered areas by abandonment of areas of low importance or vulnerability of land uses in favour of the protection of areas with land uses of high importance or vulnerability of land uses;
- decreased risk of water pollution through flooding of industrial and commercial sites or contaminated and infill sites by sea water level rise or extreme weather events;
- improved link of nature conservation with coastal protection (WBGU 2006).

Derivation of Environmental State and Impact Indicators

State Indicators

- urban settlements in designated floodplains and retention zones;
- urbanised coastal areas below sea water level and potentially from increase of sea level affected urban areas (EC 1998: Annex I, table I.2).

Impact indicators:

- land consumption in urbanised areas with special, general and inferior risk of flooding on the affected area in km² or ha;
- land use change in urbanised areas with special, general and inferior risk of flooding on the affected area in km² or ha;
- directed flooding of urbanised areas with special, general and inferior risk of flooding on the affected area and impact zone in km² or ha.

Environmental Data Requirements

- vulnerability maps with flood zones including the probability, consequences (populations at risk), and potential areas for mitigation of significant impacts (UNFCCC 2007).

Assessment Thresholds and their Methodological Derivation

The conflict of regional plan designations and objectives for adaptation to global climate change can be assessed on the basis of the vulnerability of areas below future sea water level against flooding. Coastal managers should assess the vulnerability of current and future areas below sea water level at a regional scale, in order to estimate the adaptive capacity of these areas to floods caused by rising sea water levels and tidal storms. The objective for regional land use planning is to identify and designate zones, where protection and accommodation measures should be implemented with priority, zones where certain land uses should be banned in the next decades, or zones, which will have to be abandoned to the sea.

Table 21 presents three classes of water levels in height above the basis sea water level of one metre above the current sea water level, which was derived from recommendations of the WBGU (2006). A scenario baseline was a water rise of one metre based on pre-industrial water levels by 2100. The proposed coarse classification will have to be modified for specific forecasts for coastal parts of a region. The thresholds are based on the assumption that best practice coastal technical flood measures, e.g. flood gates, dikes, retention areas and ditches, are in place to protect large-scale coastal shores against floods with the lowest possible risk of harm. Information will be required on coastal population densities and infrastructure. Additional criteria should be used to classify the effect of abandonment or directed flooding of areas on a certain number of inhabitants or in form of a potential loss of cultural and social infrastructure in a region.

Table 21: Estimated Importance of urban areas in risk of flooding for LUCCA 4

(5) Special Importance:	Urban areas in designated floodplains and retention areas; Coastal urban settlements of high population density below sea water level; Coastal areas < - 1 m below future sea water level of one metre increase compared to pre-industrial times;
(3) General Importance:	Coastal urban settlements of moderate population density below sea water level; Coastal areas > - 1 m below future sea water level of one metre increase compared to pre-industrial times and further potentially from increase of sea level affected areas;
(1) Inferior Importance:	Coastal urban settlements of low population density below sea water level; Coastal areas above future sea water level of one metre increase compared to pre-industrial times and not from increase of sea level affected areas;

Classification of Conflict Intensity

High conflicts occur for regional plan designations such as urban areas, industrial sites, commercial sites or infill sites, which are planned on coastal areas or floodplains of special importance of the vulnerability against flooding (see table 22). A regional land use plan should then propose alternative site developments on areas above future sea water levels, which are characterised by a low flood risk level. Zones for low densely populated areas to be temporarily and directed flooded

or zones with a future need of abandonment to the sea should be designated in a regional plan as a framework for the implementation of adaptation and mitigation measures at lower planning tiers.

Table 22: Conflict intensity of LUCCA 4

Assessment of the environmental impacts on the individually affected area and impact zone (5) = Special importance, (3) = General importance, (1) = Inferior importance			
Conflict Intensity	**Effect of impact factors/impact indicators on the affected area and impact zone with importance according to the assessment of the environment**		
	Land Consumption	**Land Use Change**	**Directed Flooding/ Abandonment of Urban Areas**
1. High Conflict	5, 3	5	5
2. Medium Conflict	–	3	3
3. Low Conflict	1	1	1
Positive Environmental Impacts	Assessment in comparison of alternatives of site-specific REP contents: Designated priority areas for technical flood prevention measures Designation of areas for the shift of dikes and the remediation of floodplains		
Adaptation measures	Designation of banning zones for new urban and industrial developments in coastal areas below - 1 m from basis sea water level; Designation of highly vulnerable areas with high urban densities below sea water level; Designation of emergency flood areas in coastal areas, which are abandoned and allowed to be flooded in cases of high quantity of sea water;		
Tiering	Establishing a framework for lower planning tiers for areas of low flood risk for the development of long-lasting power plants, health care infrastructure etc.; Site-specific assessments of the importance and vulnerability of land uses, particularly in very low and very high urban densities at lower tiers; Implementation of technical flood prevention measures in areas of priority.		

Interim targets should be set at regional plan level as a result of close cooperation with at least the sectors of water management, integrated coastal zone management, landscape planning and agriculture. "*The process of drawing up coastal protection plans and strategies for the sustainable use and development of coastal zones must integrate all key policy spheres*" (WBGU 2006: 2). Particularly regional targets for measures of anticipated resettlements and abandonment of urban areas should be set in a transparent process and should be made subject to public participation.

5.3 Indicators for Land Uses of Importance for the Protection of the Structure and Function of Ecosystems

Concurrent with change induced by the global climate (see chap. 3.3) the biological diversity of

species and biocoenosis is endangered through a continuously increasing large-scale intensification of land uses. The loss of open landscape, its fragmentation and impacts on ecological processes are an essential problem and precaution field. The indicators LUCCA 5-7 aggregate the components and functions of nature and landscape to be protected for flora, fauna and biodiversity and to store water and carbon in vegetation and soil. The components should include potentials of land uses to support the adaptation by changes of habitats and species populations influenced by climate change as far as possible. Regional planning should contribute to the human-induced regression of biodiversity in the EU regions, the EU Member States and bordering areas, in order to remediate and enhance a high level of biological diversity.

5.3.1 LUCCA 5 – Areas with Potential as Refugia or Corridor of the Ecological Wildlife Network

As higher average temperatures of climate change will increase the thermal stress on many animal and plant species, a vast European wildlife network is essential to "*help threatened species to migrate as habitats are lost*" (Cairncross 2006). A general shift of the species composition of ecosystems from the Southern parts of Europe towards the North, the immigration of neophytes and regional, national and European extinction of certain species is not avoidable (see chap. 3.3).

The objective of an adaptation of regional ecological wildlife networks to changing abiotic conditions is to increase the adaptive capacity of fauna and flora through a) access to refugia during extreme weather events and b) an improved network of corridors for migration. The overall objective is to reduce the risk of European native species to become extinct in the near future by conserving and improving the Natura 2000 network (after EC Habitats and Wild Birds Directive). Agricultural and forestry management will have essential responsibilities for the maintenance and restoration of multifunctional landscapes (e.g. high nature value extensively used grassland) that provide habitat and assist migration for numerous species (EC 2007a: 14, 17f; CCW et al. 2004b: 6).

Definition

LUCCA 5 is defined as areas with current and future potential to provide unfragmented large-scale natural and semi-natural habitats as refugia for species of fauna and flora, which are connected with corridors as migration paths. Ecological wildlife networks allow the exchange of individuals of species of different populations or their parts between habitats, in order to safeguard the survival of species in their natural range through genetic exchange, rehabilitation etc.

Regional Environmental Orientation Objectives

- improved and safeguarded large-scale connected regional wildlife corridor network for fauna and flora;
- ensured integrity, coherence and connectivity of the Natura 2000 network;
- implemented equivalent national environmental objectives of minimum area shares to be designated and protected as biotope connection network at regional level [e.g. in Germany 10 % of the national territory is strict legally-binding protected according to BNatSchG Art. 3; protection of 10-15 % of the unpopulated area of the year 1998 as ecological priority areas for the development of a biotope connection system by 2020 (BMU 1998: 54)];

- conserved and restored biodiversity and ecosystem services;
- maintained and restored multifunctional landscapes that provide habitat and assist migration for species;
- protected habitats with regional flagship species of the flora, with potential as refugia for international, national and regional animal species in periods of extreme weather events;
- protected current and potential regional migration corridors for fauna and flora;
- safeguarded unfragmented areas and defined limit thresholds for an effective width of patterns of the region.

Derivation of State and Impact Indicators

The overall objective of LUCCA 5 is to increase the chance of European native animal and plant species to deal with adverse impacts of climate change, i.e. reduce their vulnerability and enhance their resilience. Therefore environmental state indicators are to be derived, which assess regional land uses on their future potential as wildlife refugia and/or migration corridor.

State indicators:

- biotope connection areas and elements with transnational, national and regional importance;
- land uses with future potential to function as refugia or migration corridors for European, national and regional flagship species;
- unfragmented areas.

Impact indicators:

- land consumption of biotope connection areas and elements or land uses with potential to function as refugia and/or migration corridor of special, general or superior importance in ha;
- land use change of biotope connection areas and elements or land uses with potential to function as refugia and/or migration corridor of special, general or superior importance in ha;
- fragmentation/barrier of biotope connection areas and elements or land uses with potential to function as refugia and/or migration corridor of special, general or superior importance in km and rest area share in %;
- change of water balance affecting biotope connection areas and elements or land uses with potential to function as refugia and/or migration corridor of special, general or superior importance in ha;
- directed flooding affecting biotope connection areas and elements or land uses with potential to function as refugia and/or migration corridor of special, general or superior importance in ha.

Environmental Data Requirements

- biotope types mapping;
- scenarios for shift of biodiversity;
- red Lists of endangered species;
- ecological wildlife network Natura 2000;
- international and national nature conservation sites;
- regional biotope connection areas and corridors.

Assessment Thresholds and their Methodological Derivation

In a first step international nature protection sites, nationally protected areas and protected biotope types for nature conservation (legally-binding taboo zones or restrictions) have to be identified (see

chap. 4.4.1). Beyond protected sites, all biotope types are included, where protected species of the EC Habitat or Wild Birds Directive or of Annex I national Protection of Species Ordinance, or national Red Lists of protected species and especially rare animal and plant species occur. The composition of the fauna and flora in these areas will shift with climate change, but their importance for adaptation will remain high in a medium-term, due to their natural and cultural regional characteristics. Specific assessment criteria should be determined at lower land use planning level, taking area-specific forecasts for climate change into consideration.

Landscape planners should revise current evaluations according to the vulnerability and future potential of ecosystems and land uses to function as refugia and/or migration corridor for European, national and regional flagship species such as:

- priority areas of the regional biotope connection network, minimum area sizes and minimum width of corridors and its connectivity to neighbouring ecological networks;
- regional biotope types of importance for the regional flagship species spectrum and internationally, nationally or regionally endangered or rare species;
- Regionally important unfragmented areas;
- Additional land uses with future potential to function as refugia (water availability, vegetation providing shadow and protecting against heavy wind, soil conditions) or migration corridor extending the existent ecological network.

a) Regional biotope types

Current national protected and endangered Red List biotope types and flagship species serve as guidance for the assessment of the future importance of regional biotopes for the ecological network in a region (table 23).

Table 23: Assessment of the national protection status of biotope types for Saxony

(Source: changed from Bastian & Schreiber 1994; LfUG 1999b)

(5) Special Importance:	<u>Biotope and habitat types of national and sub regional importance, particularly sub regional bird resting areas:</u> Class 1 – very high: strongly endangered and in their existence regressing biotope types with high sensitivity and partly very long regeneration time, habitat for rare and endangered species, mostly high grade of naturalness and extensive or no use (protected biotopes in connection with Red List of biotope types); Class 2 – high: Moderately endangered, regressing biotope types with medium sensitivity, long to medium regeneration time, important as habitat for partly endangered species, high to medium level of naturalness, moderate to low intensity of use, only conditionally replaceable, (biotopes from selective biotope map without protected biotopes in connection with Red List of biotope types, class of endangering 3 and p).
(3) General Importance:	<u>Biotope and habitat types of regional importance:</u> Class 3 – moderate: widely spread, not endangered biotope types with low sensitivity, can relatively fast regenerate, as habitat relatively low importance, hardly endangered species, medium to low level of naturalness, moderate to low intensity of use, (Red List of biotope types, class of endangering).

(1) Inferior Importance:	Class 4 – low: common strongly anthropogenic influenced biotope types, as habitats nearly without importance, low level of naturalness, high intensity of use; Class 5 – very low: very heavily impacted, devastated respectively soil sealed areas.

b) Unfragmented areas

Unfragmented areas of special and general importance should be part of the regional biotope connection network. In Saxony these are defined as areas in the outside of intensively used transport and urban areas, which are not fragmented by corridors of linear elements such as sub-local roads with an average daily traffic volume of over 2000 vehicles or by two-lane railways. Physical disturbance of wildlife is caused by barriers and collision, which is subject to EIA (SMI 2003a: 34, principle 4.2). Unfragmented areas larger than 40 km^2 shall be protected against further fragmentation in Saxony (table 24), in Germany unfragmented areas with a size of > 64 km^2 (UBA 2003).

Table 24: Assessment of unfragmented Areas in Saxony

(Sources: SMI 2003a; Walz & Schumacher 2000, 2005)

(5) Special Importance	Unfragmented areas > 100 km^2; Transnational unfragmented open spaces.
(3) General Importance:	Unfragmented areas > 40 km^2 and ≤ 100 km^2.
(1) Inferior Importance:	Unfragmented areas ≤ 40 km^2.

Unfragmented areas are not only essential for the species, due to higher possible distances from noise and pollution sources of human developments, but also as a larger space for mobility and escape in the case of natural disasters or hazards, which are predicted to intensify in their effect with climate change. A more detailed regional assessment of the state of environment in the future could involve the definition of limit thresholds for the effective width of patterns in a region. UBA (2003) proposed for Germany threshold limits as share of the effective width of patterns at: < 10 km^2 of less than 1.5 %, 10-20 km^2 of less than 1.9 %, 20-35 km^2 of less than 2.2 % and > 35 km^2 of less than 3 %. BfN (2007) proposed a national target of 23 % of the area to be preserved as unfragmented undisturbed areas in Germany.

The assessment of the fragmentation intensity of protected biotope types and small-scale elements for nature conservation in SEA-REP can be based on the assumed area share of an affected area, which is occupied by small-scale biotopes and individual species (table 25). This method can be derived from the enhanced environmental risk assessment of transport planning. This sectoral planning traditionally identifies, evaluates and compares alternative alignments on their conflict intensity of significant large-scale degradation of the land and natural resources. It applies safe minimum standards for the prevention of irreversible environmental damage (Gühnemann & Rothengatter 2000). The risk of impacts on nature reserves was assessed in German Federal

Transport Planning (BVWP) by a classification on the basis of the area share of nature reserves (for Baden-Württemberg e.g. 0-10 %; 10-25 %; 25-50 %, 50-70 %) (UBA 1997a). At regional planning level this can be adapted for the density of areas with small-scale protected biotopes such as terrestrial dunes, swamps, moors etc.. A more detailed assessment is tiere down.

Table 25: Assessment of the risk of fragmentation of protected biotopes

(Source: on basis of UBA 1997a)

(5) Special Importance	<u>High risk, as 25-50 % of the affected area consists of:</u> - strict legally protected biotopes, natural monuments or protected landscape elements; and/or - strict legally protected species after Annex I national Protection of Species Ordinance; and/or - strict legally protected national Red List species of Class 1: species nationally threatened to become extinct or Class 2: highly nationally endangered species. Without protection measures the species can be threatened from extinction within the next ten years; and/or - other regional flagship species.
(3) General Importance:	<u>Moderate risk, as 10-24 % of the affected area consists of:</u> - national Red List species, Class 3: species endangered in large parts of the country. Without protection measures the species can be highly endangered within the next ten years or Class V: species of the warning list, which are currently not endangered, but it is worried, that they could become endangered within the next ten years, if they are further affected by specific factors or Class G: species, which are assumed to be endangered, but the actual status is unknown: species, whose taxonomic status is generally accepted and individual investigations lead to an assumption of their threat. The available information is not sufficient for a classification in the classes 1 to 3; - areas with potential for occurrence of red list species or especially rare animal and plant species.
(1) Inferior Importance:	<u>Low risk, as < 10 % of the affected area consists of:</u> - protected biotopes, protected species or particularly rare animal and plant species.

c) Connectivity of rivers

Similarly national and regional assessments of the future vulnerability and connectivity of rivers under consideration of objectives of the Water Framework Directive (WFD) and effects of climate change should be integrated into SEA-REP. For instance the current classification of the Saxon water connectivity programme (SMUL 2002) is based on the following criteria:

- a technical assessment of the connection and network function of the respective water body (under consideration of the effect of the water body on the whole water catchments area including secondary rivers and dependent wet biotopes); and
- an assessment of the water body function for the reproduction of species of the national Red List and the Habitat Directive;
- on a realistic estimation of the feasibility of measures in order to achieve a remediation of the connectivity;
- realisation of individual measures (technical, legal, economic, consideration of problematic transborder water bodies);
- advantage of measures for the achievement of the programme objectives;
- urgency in time.

These criteria will have to be challenged for an effective future migration network of rivers. Adaptation will require the setting of stricter priorities for the remediation of the ecological value and connectivity of first and secondary rivers as demanded in the WFD (table 26).

Table 26: Assessment of the connectivity of rivers for Saxony
(Source: SMUL 2002)

(5) Special Importance:	Water bodies of category I rivers of the river programme: - rivers, which are from perspective of nature conservation and water ecology of national or sub-regional importance or which have a good development potential; - existence of species of the national Red List, Wild Birds or Habitat Directives, which are dependent on or connected to water bodies; - estimated high future connection function under effects of climate change.
(3) General Importance:	Water bodies of category II rivers of the river programme: - water bodies, which fulfil the aforementioned criteria fully or partially and which are mainly of regional importance of concerns of nature conservation and water ecology; - estimated medium future connection function under effects of climate change.
(1) Inferior Importance:	- other water bodies, which are expected to have a very low future connection function under effects of climate change.

The importance of semi-natural meanders or river sections will increase in the future, because of ecological reasons such as migration of fish, amphibian and other water organism species, but also for flood prevention (see chap. 5.4.5). LUCCA 12 measures the retention ability of remediated river beds with formerly disturbed connectivity and anthropogenic barriers. Constructed dams, levels and water power plants reduce the potential of rivers for adaptation of migrating animal populations to climate change. Regional planning should contribute to the prevention of further degradation of key European rivers, whilst technical mitigations of fragmentation will be implemented at project level.

d) Priority areas of the current and future regional biotope connection network

In a second step an assessment of the importance of priority areas of the draft regional plan of the current regional biotope connection network and its connectivity to neighbouring ecological networks under climate change should be carried out (table 27). In the context of climate change further analysis of land uses with future potential to function as refugia (with for instance water availability, vegetation providing shadow and protecting against heavy wind, soil conditions) or migration corridor for wildlife, extending the existent ecological network, will be necessary. An essential step is to assess the naturalness and biodiversity value of all land uses within an entire region with the help of existing land cover and habitat information and objectives for development of nature and landscape under spatially-relevant effects of climate change. Types of areas shall be classified on the basis of their naturalness and biodiversity value under consideration of changing abiotic and biotic conditions. The approach of the Irish Environmental Protection Agency includes values for land use types not included in the present designation system, which could potentially act as corridors and stepping-stones in the future (EPA Ireland 2002: 54). It is deemed to be flexible for an integration of shifting climate, soil, water and vegetation conditions in the future. The outcome of a regional-specific analysis, to be carried out in Germany by ecologists and

landscape planners, shall be an identification and assessment of biodiversity as an important future resource, which dynamically reacts on and adapts to changed abiotic parameters.

Table 27: Assessment of current and future biotope connection areas and corridors

(Source: partly adapted from EPA Ireland 2002)

(5) Special Importance:	Biotope connection areas and corridors of national and sub-regional importance, particularly sub-local bird migration corridors; Areas with future potential and importance as biotope connection areas and corridors; Land uses highest in current naturalness, which contain areas of priority importance for biodiversity.
(3) General Importance:	Biotope connection areas and corridors of local importance; Land use types not included in the present designation system, which could potentially act as corridors and stepping-stones in the future; Land uses of regional ecological significance.
(1) Inferior Importance:	Areas without or with low importance for biotope connection; Land uses without potential to function as biotope connection area or corridor.

A well connected future-oriented regional biotope connection network for terrestrial and water ecosystems should be established. The network should be ideally connected to neighbouring region's networks (particularly in the North). The vulnerability and importance of regional biotope types should be reassessed under consideration of spatial effects of climate change, and classified in at least three classes on the basis of the current and predicted future biotope type and land use map of a region. The quality of the regional habitats of the wildlife network will depend on the future characteristics and functions of each biotope type. An efficient regional biotope connection network includes, beside areas, linear landscape elements such as hedgerows, tree avenues, ditches and brooks etc., whose importance under climate change have to be assessed at the lower tier of land use planning. All habitats designated as priority areas for biotope connection in a regional plan should be well connected by corridors of minimum ecological value and dimensions. Kaule (2000: 56) proposed a minimum area width of migration corridors of ≥ 300 m for large flagship species. Corridors of a minimum of 100 m width with a future potential to be extended are recommended for small flagship species.

Classification of the Environmental Conflict Intensity

The conflict intensity is assessed for each parameter individually. Table 28 presents the classification of the assessment of impacts of regional plan designations affecting biotope connection areas in OL-NS as an example.

Table 28: Conflict intensity of LUCCA 5

Assessment of the environmental impacts on the individually affected area and impact zone (5) = Special importance, (3) = General importance, (1) = Inferior importance					
Conflict Intensity	**Effect of impact factors/impact indicators on the affected area/impact zone with importance according to the assessment of the environment**				
	Land Consumption	**Land Use Change**	**Fragmentation/ Barriers**	**Change of Water Balance**	**Directed Flooding**
1. High Conflict	5, 3	5	5, 3	5	–
2. Medium Conflict	–	3	–	3	5, 3
3. Low Conflict	1	1	1	1	1
Positive Environmental Impacts	Assessment in comparison of alternatives of site-specific REP contents: Afforestation sites, which are linked to Natura 2000 and are adapted to future climatic conditions within the geographic context of the landscape; Flood protection sites (to be assessed case-by-case).				
Mitigation and adaptation measures	Designation of priority areas for a regional biotope connection network; Designation of priority areas as refugia during extreme weather events for certain regionally important animal species; Designation of priority areas as migration corridors for fauna and flora under consideration of effects of climate change; Designation of priority areas of land uses with future potential for the protection of biodiversity under changed climatic conditions.				
Tiering	Detailed site-specific assessments of biotopes and land use types on their future importance for biodiversity as an important resource adapted to changed climate conditions; Particularly the significance of land use change, a changed water balance or directed flooding must be assessed in more detail in SEA at lower planning tiers.				

Listed restrictions are summarised for all individual components of LUCCA 5. The presented conflict classification will have to be modified by regional sectoral experts after a regional-specific assessments of the parameter of tables 23-27.

Interim targets should be defined for:

- an assessment of the vulnerability, resilience and adaptive capacity of regional biotope types to climate change;
- amendment of the current regional biotope connection network in the context of impacts of climate change;
- introduction and implementation of monitoring indicators for adaptation of the regional biodiversity to climate change (e.g. ‘change of shift of species spectrum through climate change’; ‘change of populations of flagship species, which mainly support an ecosystem’).

5.3.2 LUCCA 6 – Forested Land

The protection and target-oriented management of forested land requires serious consideration

under a changing climate, as it functions as water and carbon sink of the global climate system, due to its effect on evaporation and energy balance. It will also gain importance for biomass production, cold air production and as area for human recreation and biodiversity, to an extent, which depends on its ecological condition and management (Art. 1 BWaldG) (see chap. 3.3.1). In Germany forests generally cannot be distinguished between forests for the harvest of timber and forests protected for recreation, landscape and nature. The objective is a multi-functional forestry on the entire managed area, which is weighed with social needs. Large-scale deforestation does not occur in Germany (BMU 1997, 2000).

The objective of this indicator is to increase the awareness of regional planners on the interrelations of the regional tree cover with groundwater development, the water balance and carbon sequestration (i.e. the balance of uptake and storage of carbon). Experts from forestry identify adaptation measures for the species composition of European forests and woodlands to climate change, as certain tree species such as the spruce start to struggle with dry and hot summers. Adaptation strategies of the economy of the forestry sector – in terms of its regional potential for timber generation as a native renewable resource – very much depend on soil, air and climate conditions (Klein 2004). In forestry mitigation of carbon release and adaptation are equally necessary.

Different methods for the mitigation of carbon release and increase of carbon sinks through land use change were investigated (WBGU 2003). Schulze (2006: 15) found that the protection of forest from wood extraction in Europe would have a long-lasting effect on carbon sequestration, although this is not accountable as a carbon sink in the Joint Implementation and Clean Development Mechanism of the Kyoto Protocol. Schelhaas et al. (2007: 10) also concluded that the measure of "*protection of forests with high carbon stocks*" would avoid a large carbon source from harvesting. But they stated this measure is not as effective as afforestation, as in the longer run these high stocks would decrease earlier, due to natural reasons such as age-related mortality and natural disturbances. In the same way a more target-oriented (with increase of the carbon sink) management of forests in Europe could increase the total carbon uptake for the next decades. However, this would only in the short-term contribute to mitigation, as after a few decades the storage capacity of the biosphere would be saturated or would become a carbon source through climate or land use change (Janssens et al. 2003). Consequently, planning for land use change of open unvegetated land to forested land remains less effective, than the reduction of anthropogenic emissions from industry and transport (IPCC 2000). Mitigation has the highest effect in Eastern Europe (particularly in Siberian boreal woodlands) with the maintenance of previously unmanaged forested land with high potential as carbon sink (Schulze 2006: 15). Important measures of forestry management in terms of carbon sink enhancement are increased rotation length and increased thinning (Schelhaas et al. 2007). However, extending rotation times would rather delay emissions, instead of creating new carbon sinks (Schulze 2006: 15).

In central Europe adaptation of forestry will be most important. As for instance German forest management already operates at a high level of carbon stock, the options for a further increase in stocks are very limited (Schulze 2006: 15). Deforestation on a large scale is prohibited in the EU, and is rather a problem in tropical rainforests of developing countries (Moors & Dolman 2003: 144). An immediate adaptation of forests to effects of increasing air temperature is necessary, because of the predicted time lag of 30-40 years between any significant changes in the water or carbon balance. Newly planted trees will need decades to mature, capture and store

relevant amounts of water and carbon. Forestry management has a major role to play regarding efficient water use in dry regions, protection of water courses against excessive nutrient inflow, improvement of flood management, maintenance and restoration of multifunctional landscapes such as high nature forested land that provide habitat and assist migration for numerous species. Also the promotion of climate resilient forest management and protection of permanent grasslands are mitigation measures that should help adaptation to climate change risks (EC 2007a: 14).

The promotion of stricter sustainable mixed forest management, as required in the EU Forestry strategy and national forestry action plans of the EU Member States, will significantly contribute to adaptation, as natural forest communities with native tree species can potentially adapt for a longer time to climate change, than species not suitable to a habitat. Native broad-leaved tree species have the advantage of not loosing water in the winter season, of storing carbon for a longer time period, than relatively fast growing conifers, and of contributing to the development of organic soils as carbon store, whilst certain adapted species (e.g. of the families of arecaceae or neophytes for Northern Europe from South European or Asian countries) will be potentially more aridity and heat resistant in summer. A good measure for adaptation to changes of climate, soil and water is considered as a mixed natural forest community with a sufficient distance of tree species to ecological habitat edges [i.e. in Germany mainly the beech (*Fagus sylvatica*)] (Kölling 2006).

Definition

LUCCA 6 describes current and planned forest and woodland resources in a region, which are of importance for the storage of water and carbon and have a potential to enhance this function in the future. The indicator measures the ecological status (i.e. with future regional-specific data the assessed adaptive capacity) and level of adaptation of the management of native mixed woodlands and monoculture forests as well as their potential to function as carbon and water sink.

Regional Environmental Orientation Objectives

- prohibited deforestation on a large scale;
- strictly protected natural woodlands with high carbon stocks;
- maintained previously unmanaged forested land with high potential as carbon sink;
- promoted climate resilient forest management: protected and enhanced woodland habitats and associated species, safeguarded permanent vegetation cover and increased rotation periods and thinning for prevention of soil erosion, flooding, negative balance of the carbon and water storage capacity, facilitated resilience and adaptive capacity to climate change;
- implemented national targets on increase of the area share of native woodland at the forested area, adapted to climate change and in conformity with the natural and geographic context of the region (not on fertile land needed for agriculture (see LUCCA 9);
- achieved positive ratio (≥ 1) of afforested area divided through deforested area taking the level of degradation and compensation of the lost area at another place into consideration.

Derivation of Environmental State and Impact Indicators

State indicators:

- existent and future public and private forested land, which is harvested for timber according to national forestry management standards, including preservation from soil erosion, loss of native tree vegetation, the capacity of carbon and water capture and storage.

Impact indicators:

- land consumption of forested land of superior, general and inferior importance for adaptation to climate change and capture and storage of carbon and water on the affected area in ha;
- land use change of forested land of superior, general and inferior importance for adaptation to climate change and capture and storage of carbon and water on the affected area in ha.

Environmental Data Requirements

- forestry vulnerability mapping of climate variables and climate risks;
- water retention and storage capacity of existent forests;
- carbon storage capacity of forested land types and tree species;
- level of degradation and productivity of forests under climate change scenarios.

Assessment Thresholds and their Methodological Derivation

The state indicator of LUCCA 6 shall measure the capacity of natural woodlands and forested lands, managed according to the best practice codes of sustainable forest management and the conservation of special environmental values, to adapt to climate change and to function as sink for carbon and water (EC 1998 Annex III, table III.3). Essential designations of regional planning, which were integrated from forestry management plans, are priority areas for the safeguarding of existent forests and afforestation sites. Regional-specific data of forestry planners on the adaptive capacity of regional forests will be required for an efficient adaptation and protection of forested land. Important parameters for the assessment of the environmental potential of wooded areas will be minimum standards of sustainable forest management with long rotation periods, open spaces, woodland edges, various ecological structures and a certain proportion of mature and newly planted trees. Further research of the carbon cycle and on reducing carbon emissions should take full account of areas where large pools of organic carbon are stored – or are being released (Schulze & Freibauer 2005: 206). Forest experts might also deliver data on the optimised length of rotation and thinning share with respect to the expected carbon gain. This may represent a benchmark for classical forest management system of different age classes to aim for (Schelhaas et al. 2007). However, further scientific research in this field is necessary, to promote an efficient adaptation of the regional plan designation for priority areas of forestry protection and afforestation.

Compared to the size of other measures, afforestation is expected to have a small but sustainable impact on carbon sequestration, which will likely increase with the establishment of more productive stages of the ecosystem. It is classified according to the general importance for adaptation and capture of carbon and water storage, primarily based on the age of newly planted trees. Schelhaas et al. (2007: 16) quantified the enhancement of the carbon sink through increased rotation lengths and/or thinning intensity for up to 61 % above the baseline. However, the potential of afforestation, its designation in forestry plans and integration into regional planning depends largely on the availability of abandoned agricultural land, as highly productive agricultural land is secured for food production (LUCCA 9). Thus afforestation is mainly an adequate mitigation and adaptation measure in Eastern Europe, where both available land and low labour costs are available.

Table 29: Estimated adaptive capacity and function for carbon and water capture and storage of state and communal woodlands and forests

(Sources: modified from LAF 1996: table 12, p. 42; PÖU et al. 1993; Roch 2000: 59; Sächsische Staatsregierung 2004: 51f)

(5) Special Importance	International and national importance for adaptation to climate change and capture and storage of carbon and water: Native natural or semi-natural woodlands, extensively used, > 60 years old trees, rotation periods of over 60 years; Tree species composition of the native woodland plant community or close to this (> 50 % of the composition are tree species, which are adapted to the natural habitat); [Mixed natural forest community (> 70 % share of broad-leaf) with a sufficient distance of tree species to ecological habitat edges].
(3) General Importance	Regional importance or future potential for adaptation to climate change and capture and storage of carbon and water: Tree species composition of < 50 % of tree species of the native woodland society (primary and secondary tree species); Afforested or reforested sites, transitional woodland shrubs; Species including neophytes, which are well adapted to climate change; Forests far from nature, intensively used, at the borderline of best practice forestry; (Mixed forests with > 30 % share of broad-leaf respectively coniferous tree species).
(1) Inferior Importance	No regional importance and future potential for adaptation to climate change and capture and storage of carbon and water: Highly damaged not native (coniferous) monocultures; Forests characterised by vegetation-free areas, plant species of nutrient-rich sites; Forests far from a natural state; intensively used; very common biotope types; limited possibility of remediation, dependent on age of trees; Forested land, which is not accessible or its state and development is unclear.

Modifications of table 29 on the basis of regional-specific assessments of the adaptive capacity of woodlands and forests will be necessary.

Classification of the Environmental Conflict Intensity

Table 30 presents the conflict intensity of adverse impacts of regional planning on forested land, based on its importance for adaptation to climate change and capture/storage of water and carbon. Sector experts will have to operationalise this proposal for regional-specific conditions, taking regional spatial climate effects into account. The main positive effect consists in an ecological upgrading of existent forests. At regional plan level the forest sector authorities should revise their forestry framework plans (e.g. Art. 7 Federal Forest Act, BWaldG). It is not a new fact, that site-specific regional data will be needed on predictions of the local changing temperature and precipitation (Burschel & Huss 1997: 25). In Germany forests are distinguished between protection forest, forests planted as protection against avalanche and recreational forest (Arts. 12 and 13 BWaldG). Under climate change an additional designation should be the capacity of forests and woodlands for capture and storage of water and carbon (particularly in boreal forests) and their re-

Table 30: Conflict intensity of LUCCA 6

Assessment of the environmental impacts on the individually affected area (5) = Special importance, (3) = General importance, (1) = Inferior importance		
Conflict Intensity	**Effect of impact factors/impact indicators on the affected area with importance according to the assessment of the environment**	
	Land Consumption	**Land Use Change**
1. High Conflict	5	5
2. Medium Conflict	3	3
3. Low Conflict	1	1
Positive Environmental Impacts	Assessment in comparison of alternatives of site-specific REP contents: Priority areas for afforestation; Reserve areas for the preservation of existent forest or afforestation of the regional plan must not overlap with conflicting area designations.	
Mitigation and Adaptation Measures	Designated afforestation sites according to strict regional-specific designation criteria and priorities such as avoidance of productive agricultural soils, extensions of existent forested areas and slopes of arable land, which are threatened by water or wind erosion (see RPV Mittlerer Oberrhein 2003, 2005); Designation of afforestation sites in former mining areas, areas where flooding originates and areas where forest is sparse; Designation of afforestation areas with a share of > 50 % native tree species and strict compliance with sustainable forest management with long rotation cycles; Designation of climate protection forests; Strictly implementing designation criteria for afforestation areas such as: - low productivity of the soil; - high erosion risk; - low water retention ability; - low share of climatically important structures; - connection to biotope connection areas or corridors; - increasing the capacity for water and carbon storage in the region.	
Tiering (to forestry)	Assessment of regional tree species, which can best adapt to climate change, on optimum rotation and thinning periods and on best practice criteria of sustainable forest management with the objective to enhance the storage of water and carbon; Create a guidance framework for lower planning tiers on the implementation of afforestation sites.	

sistance against stress caused by climate change. Regional forestry management plans will have to deliver adaptation criteria to be integrated into REP, which are ideally linked to greater biological and landscape diversities (link to LUCCA 4).

5.3.3 LUCCA 7 – Biotope Types with Potential for Water Capture and Storage

In the EU a proceeding loss of not forested vegetated land such as heath, tundra and wetlands is monitored (EEA 2005a). Land covers of grasslands, heathlands, moors and wetlands have a certain potential for the capture and storage of water and carbon, as a mitigation of release to the atmosphere (UBA 2006; EC 2007a: 14). Degradation of terrestrial ecosystems and wetlands and their water regimes are prohibited (Art 1. WFD). Even if the area share of these areas is relatively low – for instance wetlands covered only 1 % of the European territory in 2000 (EEA 2005a: 41) – an adaptation of the land use to climate change at regional planning level should first of all prevent any conflicts with possible measures for the capture and storage of water. The mitigation of carbon release is an additional positive effect. In the context of environmental precaution it is assumed that the larger the area of functioning natural ecosystems and biotopes with importance for the water regime in a region is safeguarded, the better is the rank of a region in the field of area-wide adaptation in Europe.

Definition

The state and impact indicators of LUCCA 7 shall measure adverse impacts on regional biotope types with importance for capture or storage of water (and carbon). This capacity of biotope types will be potentially influenced under climate change by factors like the groundwater level, precipitation rate and frequency, exposure towards sunshine and wind, as well as geological soil conditions.

Current areas with a high level of groundwater below ground are deemed to be of importance for future biotope development and water storage at extreme locations. A groundwater-dependent ecosystem is a connection of biotopes, whose typical habitat community depends on a high groundwater level below ground (SMUL 2005: 34). The level of groundwater below ground is the distance between soil surface and groundwater surface. It influences the sensitivity of the groundwater regime and protects ecosystems dependent on it, such as wetlands against a change by water abstraction.

Regional Environmental Quality Orientation Objective

- maintained permanent grasslands, heathlands, moors and wetlands;
- safeguarded biotopes with high potential for water (and carbon) capture and storage (managed forests: see LUCCA 6);
- safeguarded and remediated groundwater balance in a region.

Derivation of Environmental State and Impact Indicators

State indicator:

- biotope types dependent on a high groundwater level;
- biotope types with capacity of water (and carbon) capture and storage (managed forests: see LUCCA 6).

Impact indicators:

- land consumption of biotope types dependent on a high groundwater level or with superior, general and inferior importance for water capture and storage on the affected area in ha;
- land use change of biotope types dependent on a high groundwater level or with superior, general and inferior importance for water capture and storage on the affected area in ha;
- change of water balance affecting biotope types dependent on a high groundwater or with superior, general and inferior importance for water capture and storage on the affected area and impact zone in ha.

Environmental Data Requirements

- geological maps with groundwater levels;
- biotope type mapping;
- vulnerability maps for areas in high risk of change of the water balance;
- data on the potential of biotope types to capture and store water under climate scenarios.

Assessment Thresholds and their Methodological Derivation

Sectoral experts should provide regional predictions as result of an assessment of biotope types, according to their dependency on a high groundwater level below the soil surface and future vulnerability under effects of climate change. The assessment is a part of the implementation of the EU Water Framework and groundwater protection directives in combination with adaptation objectives.

Table 31: Estimated importance of biotope types for water (and carbon) capture and storage

(5) Special Importance	Biotope types with international and national importance for water capture and storage: Biotope types (water bodies, wetlands, swamps, wet range and grassland) dependent on groundwater level of < 2 m below ground (example for OL-NS) with a high future water recharge potential; Biotopes types (wet forests or scrublands) dependent on groundwater level of ≥ 2 m with a high future water recharge potential; Intact heathlands, moors and extensively managed grasslands affected by a frequent and high future precipitation rate.
(3) General Importance	Biotope types with regional importance or future potential for water capture and storage: Drained former wet ecosystems, which can be renaturated by closing dykes and remediating the water balance (e.g. pastures, set aside agricultural land).
(1) Inferior Importance	Biotope types without future potential for water capture and storage: Not vegetated biotopes; Highly damaged and drained former wet ecosystems, which cannot be renaturated; Biotopes which are not part of the scope of investigation, are not accessible or their development is unclear.

For the region OL-NS in Saxony areas with average groundwater levels below ground of less than two metres were classified as highly dependent on the groundwater (water bodies, wetlands, swamps, wet range and grasslands) (LAWA project principle 1.01, 2003: 4f). Further relevant biotope types for the regional water regime are wet forests or scrublands with ground water levels

above two metres. Based on the assessment of national biotope types – in Germany for instance carried out according to Wiegleb et al. (2002), Lenkenhoff & Rose (2002), Petersen & Sütering (2003) – regional biotope types with special importance for the capture and storage of water should be identified. Their potential for water capture and storage should be estimated and revised according to new research for at least one generation cycle (approximately >50 years). Wet terrestrial ecosystems influenced by high groundwater levels can act as carbon sink, as long as their water regime stays unharmed by regional development leading to drainage. In the long-term under a changed climate these ecosystems will be affected by temperature increase, likely dry out and therefore release the carbon, which was stored before. The threshold values in table 31 will have to be modified for the specific natural conditions and potentials of a region.

Classification of Conflict Intensity

The proposal of conflict intensities for LUCCA 7 (table 32) is subject to a high level of uncertainty, as hardly regional-specific data was used to estimate the potential of biotope types for water capture and storage.

Table 32: Conflict intensity of LUCCA 7

Assessment of the environmental impacts on the individually affected area and impact zone (5) = Special importance, (3) = General importance, (1) = Inferior importance			
Conflict Intensity	**Effect of impact factors/impact indicators on the affected area and impact zone with importance according to the assessment of the environment**		
	Land Consumption	**Land Use Change**	**Change of Water Balance**
1. High Conflict	5	5	5
2. Medium Conflict	3, 1	3	3
3. Low Conflict	–	1	1
Positive Environmental Impacts	Assessment in comparison of alternatives of site-specific REP contents: Designation of afforestation sites (case-by-case analysis).		
Mitigation and Adaptation Measures	Renaturation of drained former wet ecosystems by increasing groundwater levels, integrations from water management plan with recommendations for adaptation to climate change after Water Framework Directive; Designation of priority areas for water capture and storage; Designation of priority areas for groundwater remediation; Designation of priority areas for remediation of nature and landscape.		
Tiering (to agriculture and water management)	Site-specific more detailed assessments as part of agricultural and water management plans; Groundwater remediation; Extensification of grasslands; Designation of set aside land as ecological areas; Formulation of adaptation requirements for binding land use plan.		

The supply of high quality drinking water in the European regions will rely very much on technical solutions for water storage in times of water scarcity such as reservoirs and cisterns. Moreover urgent actions to prevent from water pollution as postulated in the WFD are vital.

Sectoral experts of geology, water management and landscape framework planning shall carry out revised assessments of all national biotope types and their likely change under climate effects with special focus on their capacity for water and carbon capture and storage. Certain land uses to be designated and protected as priority areas for water storage and capture shall be identified beside freshwater resources, drinking water catchment areas, forests and woodlands. A common adaptation concept will be useful.

5.4 Indicators for Land Uses of Importance for the Protection of the Natural Resources Soil and Water

The natural resources of soil and water are of essential importance for the adequate supply of a regional population with high quality drinking water and agricultural food. An overall objective is to sustainably protect the soil functions for utilisation, production of food and biomass (for agriculture and forestry), water regime, regulation of temperature, buffering of acids, filtering of noxious substances, demeliorisation of toxic substances and storage of nutrients and habitat function for flora and fauna (Bracher et al. 2000: 2f). A regional management of soil and water resources according to principles of environmental precaution requires a permanent generation, preservation and storage of productive soils and water. Therefore land uses with special importance for the storage and supply of freshwater as well as the retention and absorption of precipitation and inundation water are considered in the following LUCCA 8-12. Particularly already at regional level soils have to be preserved against land consumption, erosion and degradation, if the most possible long-term regional potential for food production shall be preserved. As the water and soil conditions of a region will change with the climate, both sensitive regimes require stricter protection and a higher ecological status quo.

5.4.1 LUCCA 8 – Unsealed Soils

The soil function of being unsealed is crucial for the protection of the European soils, as soil sealing means a more or less irreversible loss of all soil functions, particularly its original fertility (UBA 2004b; BayLfU 2004: 47). „*The European soil is an immensely valuable but finite resource, which requires protection to ensure future food security and environmental quality*" (IES 2005). In the near future the demand for land for urban and transport development in the EU, leading to progressive urban sprawl and fragmentation of the landscape will further increase (EEA 2006).

In Germany the land consumption rate for settlement and transport dropped since 2001, but in view of the current intensive land use for settlement there is no guaranteed trend reversal as yet towards the target of the national sustainability strategy of 30 ha per day by 2020 (see chap. 2.2.1). In 2008 13 % of the German territory will be irreversible lost through soil sealing (StBA 2008);

Soil sealing has got cross-media negative effects on the water balance, development and storage of groundwater and the local climate, as it affects the infiltration of water into the soil, needed to recharge groundwater resources. It tendencially intensifies negative effects of climate change

through an increased air temperature in urban settlements with large-scale sealed surfaces, loss of soils, vegetation and their function of water and carbon storage. Unsealed soils will play an increasingly valuable role for high quality food production, drinking water generation, nature conservation and flood control. As worldwide currently food is "*grossly under priced in the world according to its ecological production*" (Williams 2005), its price will likely further increase in the future because of globalisation, negative anthropogenic impacts on the land as well as changed climatic conditions.

Definition

The state indicator 'unsealed soils' measures the ability of the soil to fulfil important functions of the natural regime on areas, which should be safeguarded from sealing. Soil sealing means an irreversible loss of open, unsealed areas (MLUR BR 2003). The indicator includes all soil functions of productivity of the soil, filter, storage and buffer function and biotic habitat function. Under climate change these soil functions will develop differently in different parts of Europe, and therefore environmental precaution demands a more consequent reduction of the newly sealed area share in a region as an adaptation measure.

Regional Environmental Orientation Objectives

- urban development linked to efficient public transportation infrastructure;
- reduced new soil sealing by consequently challenging the area potentials of limitations of the maximum need for housing areas, prevention of urban sprawl through revitalisations of the inner cities and more efficient housing development;
- promoted inner city development with urban infill of low-density residential districts and increase in relative housing density, whilst at the same time preserving important open green spaces;
- contributed to a shift towards urban development on previously developed vacant land, which is currently unused and may be available for redevelopment, so called 'brownfield sites';
- complied with guidance targets for minimum housing densities and regulations of maximum settlement needs;
- applied area-related limit values for housing for the own need of municipalities in the region and for inhabitants gained through migrations from outside;
- set strict legally-binding objectives for the extent of soil sealing in the outskirts of agglomeration areas and development on brown fields (see approaches of Higgins 2004; Hoggart 2004);
- set minimum standard for the protection of the area share of open spaces in municipalities of agglomeration areas.

Derivation of Environmental State and Impact Indicators

State indicators:

- unsealed soils of low disturbance (In Saxony areas not within sealing classes of 0-25 %, 26-50 %, 51-75 %, 76-100 %);
- brownfields with reuse potential.

Impact indicator:

- land consumption of areas of special, general or inferior importance for soil protection against

sealing in ha.

Environmental Data Requirements

- maps with the soil sealing share of land uses;
- population and migration forecasts and connected demographic and land use change;
- brownfields;
- soil functions under climate and land use change scenarios.

Assessment Thresholds and their Methodological Derivation

In a first step soil experts should deliver data from an assessment of the current level of disturbance and sealing grade of regional soils. The level of disturbance of soils can be estimated with the help of certain land uses (table 33). A classification from Henz (1998) was summarised to three classes of importance; the soil sealing grade was classified for Saxony (LfUG 2004a). The given sealing share of settlement and urban area consists of housing and distance spaces, transport area, recreation areas, commercial/industrial areas and areas for cemeteries. Therefore not all summarised land uses are sealed in reality to > 50 %. A regional specific hemeroby level of the soil could be used as a more specific indicator for the level of disturbance of soils in SEA at lower tiers.

Table 33: Assessment of the sealing grade and disturbance of soils
(Sources: LfUG 2004a; Henz 1998)

(5) Special Importance	Unsealed areas without the classes of soil sealing shares of 0-25 %, 26-50 %, 51-75 %, 76-100 % (for Saxony): Lowly damaged and semi-natural soil profiles for instance under extensively managed woodlands, arable land or meadows.
(3) General Importance	Areas with a soil sealing share of ≤ 25 % (for Saxony): Mixture of artificial and natural materials; Highly and moderately damaged soil profiles: pastures; vegetation along roads; gardens; modified arable land; sports grounds; gardening; maize cultures.
(1) Inferior Importance	Brownfields with a soil sealing share of > 25 % (for Saxony) and a reuse potential: Contaminated soils with potential for replacement or sanitation at project level; Secondary soils on gravel, paving, rubble or railroad embankments; Vegetation along roads with accumulation of pollutants; Compacted soils without vegetation and A horizon.

Beside the importance of the affected area, the RPB should create a guidance of minimum housing area densities for the lower binding land use planning (see table 10, column ‘soil sealing level’) (PGW 2003). These regionally calculated guidance values for the designation of new building sites of the municipalities are based on the central place system, city edges and population forecasts of conventional regional planning (Happe et al. 1999). The methodological process of the derivation of these guidance values for the designation of building sites and their compliance can be assessed in the overall strategic plan assessment as part of SEA-REP.

The Federal Office for Building and Regional Planning (BBR 2000) estimated the suitability of the German-wide reuse potential of previously used and only partially used land in 2000 for

commercial sites with 59 % and for settlement areas with 22 % (rest area shares: public uses 5 %; natural development 14 %). This justifies a future need of data on the reuse potential of brownfields of former industrial and commercial developments, less than 100 % used areas or other unused derelict or barren land at regional scale (e.g. in three classes of high, medium and low reuse potential). An assessment should consider a future environmental potential of brownfield sites for important adaptation functions such as fresh air exchange or recreation of a remediated green space. Regional planning should create a framework for brownfields with reuse potential, which will have to be specified at lower tiers.

The regional planning designation of available previously developed area potentials requires the knowledge of these locations and ideally a systematic inventory of brownfield areas, but currently for instance in Saxony there exists a lack of spatial data. The designation of urban developments on brownfields at regional planning level should therefore be specified by case-by-case decisions at lower land use planning level (tiered down), as soil sealing on an unsealed inner city area can be as negative as soil sealing of an alternative site outside of city borders. Generally the building density on converted areas is higher than on new building sites. Urban sprawl also requires new infrastructure (connection to public transport system, social facilities, waste and sewage management etc.). Similarly to brownfields, expert systems for the assessment of the vulnerability of open spaces and outskirts of cities by infill or urban sprawl are required (see chap. 5.2).

Classification of Conflict Intensity

The conflict intensity of LUCCA 8 requires regional-specific data on the current level of soil sealing in a region. Restricted to land consumption are mainly protection sites, biotopes and landscapes (see chap. 4.4.1).

Regional housing policy in the EU is often too vague and generalised. It does not clearly indicate where which density of housing development should take place. Regional planning and land use planning should create a better framework for the consequent reduction of land consumption. For this purpose, strict limits of housing development considering the population, densities and efficiency of housing sites are needed (Happe et al. 1999: 72; Storch & Schmidt M. 2008). With the REP designation of urban settlements, industrial or commercial sites or spatially-specific settlement axis, in SEA-REP the question has to be answered, if respective municipalities have access to a sufficient environmentally-sound building site potential and if the designations allow a sustainable urban settlement (Schmidt C. et al. 2004).

The first interim target is the development of regional visions and objectives for a sustainable landscape and urban development, which leads to a continuous annually reduction of land consumption. In the context of the affected urban or rural area regional-specific thresholds of land consumption shall be applied to assess current capacities of urban development. In the future in a second step data surveys on the locations of available previously developed area potentials in the region will be useful. In 2007 not all municipalities have access to a systematic inventory of their brownfield areas as a data gathering and planning basis. Regional-specific concepts for models of land registers as instruments for a communal land management should be developed by 2020.

Table 34: Conflict intensity of LUCCA 8

Assessment of the environmental impacts on the individually affected area (5) = Special importance, (3) = General importance, (1) = Inferior importance	
Conflict Intensity	**Effect of impact factors/impact indicators on the affected area with importance according to the assessment of the environment**
	Land Consumption
1. High Conflict	5
2. Medium Conflict	3
3. Low Conflict	1
Positive Environmental Impacts	Assessment in comparison of alternatives of site-specific REP contents: –
Mitigation and Adaptation Measures	Reduction of the area size of a REP designation leading to soil sealing; Implementation of quantitative limit values for soil sealing and minimum densities for new urban developments; Designation of urban, industrial and commercial sites with priority on previously developed abandoned sites (vacant land, brownfields and derelict sites) under consideration of reuse potential; Designation of brownfields with low reuse potential and high future environmental potential to be desealed and remediated as green corridor or green belt.
Tiering	More detailed assessments at lower land use planning level including criteria such as land availability and ownership, natural features and ground conditions, halt to extensive fringe development beyond city limits and targeted minimum housing densities; In individual cases there may be a need to avoid development on brownfield sites in cultural heritage sites, designated landscape areas, or where it can provide valuable urban green space.

5.4.2 LUCCA 9 – Soils for High Quality Agricultural Food Production

Urban sprawl threatens particularly often high productive soils in the urban-rural periphery of growing cities or agglomeration areas. Afforestation in Germany also often takes place on agricultural areas of the best regional quality of the soil productivity (e.g. RPV Mittlerer Oberrhein 2003, 2005). Such most productive soils are not strict legally-binding protected against land consumption.

Climate change will potentially lead to a decrease of the area share of productive soils through salinisation and erosion in arid areas and through flooding in coastal areas of certain EU regions. Additional likely negative effects of climate change will favour a loss of crop yield through scarcity of irrigation water, extreme weather events, natural disasters, more dispersed and resistant diseases or pests. Higher frequencies of irrigation activities in long periods of aridity will raise water tables and increase risks of soil salinity (see chap. 3.3).

As the original fertility of the soil is irreversible (UBA 2004b), a shift of the productivity of agriculture in Europe is expected in dependence on among other factors the natural soil fertility, the soil genesis, the future regional climatic and water conditions. Anyway prevention requires a stricter protection of current high productive soils and soils with a potential to stay fertile in the future.

Definition

The productivity of soils is its ability to sustainably produce biomass. Fertile soils are especially to be preserved from urban settlement and other adverse impacts in the context of the sustainability and precaution principle, as climate change leads potentially to more significant unforeseen damage or loss of yield.

Regional Environmental Orientation Objectives

- strictly protected highly productive soils at high groundwater development rate against soil sealing, soil compaction and erosion;
- safeguarded and increased area share for extensively managed agricultural and organically farmed land;
- set aside, change from arable land to extensively managed pastures, nature conservation and biotope development on low soil productivity (link to LUCCA 5);
- further extensified and adapted agricultural activities.

Derivation of Environmental State and Impact Indicators

State indicator:

- productive soils, assessed in soil figure for arable land and grassland (including an estimated future potential and need for irrigation, pesticides and fertilizers and intensity of management).

Impact indicators:

- land consumption of soils of special, general or superior importance of the soil productivity on the affected area in hectares;
- land use change of soils of special, general or superior importance of the soil productivity on the affected area in hectares;
- change of water balance affecting soils of special, general or superior importance of the soil productivity on the affected area and impact zone in hectares;
- dircted flooding of soils of special, general or superior importance of the soil productivity on the affected area and impact zone in hectares.

Environmental Data Requirements

- maps on the soil productivity under climate and land use change scenarios.

Assessment Thresholds and their Methodological Derivation

The soil productivity of each EU country and region should be assessed on the basis of the agricultural yield potential for different regional-specific crops (Kaule 2000).

In Saxony the current productivity of soils is assessed in three classes derived from five fertility classes (F classes) of the German soil concept map, gathered on basis of the agricultural yield

potential (table 35). The assessment of natural soil fertility is carried out on the basis of the arable and grassland point system of the soil assessment instrument of Saxony (SMUL 2005: 16).

Table 35: Assessment of the productivity of the soil for Upper Lusatia-Lower Silesia in Saxony (Source: SMUL 2005)

	F-classes	Assessment	Soil figure for arable land and grassland
(5) Special Importance:	V (F-class 5) IV (F-class 4)	very high high	> 70 51-70
(3) General Importance:	III (F-class 3)	average	36-50
(1) Inferior Importance:	II (F-class 2) I (F-class 1)	low very low	20-35 < 20

The productivity of the soil is measured as an aggregated classified value, i.e. a range of values that are aggregated from many individual values. A creation of classified variables is necessary in the course of the data analysis due to practical reasons. In comparison to the most fertile soils of the young marshlands and the so called Hildesheimer Boerde, Altmark and Magdeburger Boerde (reference value of 100 soil points) in Northern Germany with soil points of 90, the soils in OL-NS are with soil points of 70 not very fertile. The range of the values of the arable land and grassland soil figure system is divided into five classes. Each class corresponds with one fertility class (F-class) of the natural soil productivity. Three main classes for the region OL-NS were summarised.

In order to adapt the protection of soils with high productivity to climate change, data will be necessary on the assumed future soil productivity in a region. Soil experts should deliver forecasts of future soil productivity, which integrates likely alterations of the regional water availability and air temperature into the evaluation of soil figures. This will lead to a revision of current thresholds for regional soil figures.

Linked to the productivity of the soil is the agricultural land use, which is characterised by the intensity of the management in terms of mechanical activities, irrigation water, fertilizer and pesticide use. As agricultural land is privately owned and decisions on cultivation are mainly influenced by Common Agricultural Policy (CAP) funding schemes of the EU, land use change will generally have significant impacts on the preservation of the regional soil fertility or its degradation[24]. The current importance of agricultural land use for the protection of soils under different management intensities and crop diversities should be estimated (table 36). A progressive greening of the CAP and Government strategies such as subsidies focusing on an improved productivity of the soil and biodiversity in the EU regions likely contribute to a sustainable land use.

[24] As well as an essential contribution to the protection of biodiversity (see abolishment of obligatory set-aside land in the EU).

Table 36: Estimation of the importance of agricultural land use for the protection of soils

(5) Special Importance:	Ecologically set-aside land; Organically managed land; Extensively managed arable land for the cultivation of crops in need of low irrigation water, pesticide and fertilizer use; Livestock grazing on extensively managed pastures (low livestock density).
(3) General Importance:	Farmland of high crop diversity; Intensively managed arable land for the cultivation of crops in need of high to moderate irrigation water, pesticide and fertilizer use; Intensive livestock grazing (high to moderate livestock density).
(1) Inferior Importance:	Highly degraded and compacted soils; Land > 50 % sealed.

Classification of Conflict Intensity

The assessment of the environmental impacts on the individually affected area should include beside soil figures the land use intensity of an area. The conflict intensity should be derived from both assessment criteria (table 37). Predictions of pressures caused by climate change on the use of soils will have to be the basis for regional-specific evaluations in the future.

Geological experts will have to carry out case-specific assessments of the vulnerability and adaptive capacity of current moderately and highly productive soils. Agricultural planning should further include a monitoring of the regional productivity of soils and the shift of crops under climate change.

The objective of regional planning in the frame of environmental precaution with the integration of priority areas for agriculture is to protect the best and most versatile agricultural land for a medium-term sustainable high quality food production in the EU. This objective is closely linked to the prevention of soil loss by erosion (see LUCCA 10). Effects of climate change on European soils will likely necessitate a further 'ecologisation' of traditional rural agriculture and the maintenance of natural and cultural landscape elements as prevention measures for soil degradation (Troge & Hutter 2004).

Table 37: Conflict intensity of LUCCA 9

Assessment of the environmental impacts on the individually affected area and impact zone (5) = Special importance, (3) = General importance, (1) = Inferior importance				
Conflict Intensity	**Effect of impact factors/impact indicators on the affected area with importance according to the assessment of the environment**			
	Land Consumption	**Land Use Change**	**Change of Water Balance**	**Directed Flooding**
1. High Conflict	5, 3	5	–	5
2. Medium Conflict	1	3	5, 3	3
3. Low Conflict	–	1	1	1

Positive environmental impacts	Assessment in comparison of alternatives of site-specific REP contents: _
Adaptation measures	Designation of priority areas for desealing; Designation of priority areas for remediation of soil and regulation of the groundwater level with the aim to upgrade the productivity of the soil; Designation of afforestation sites and other land use changes only on arable land with soils of low productivity; Designation of priority areas for agriculture on soils with national or regional special importance of high quality agricultural food production and low artificial soil improvement including: - agricultural soils of very high and high productivity, - organically farmed land with high future potential, - extensively managed agricultural land for the cultivation of crops in need of low irrigation water, pesticide and fertilizer use, - livestock grazing on extensively managed pastures (low livestock density). - designation of areas, which are provided for biomass production.
Tiering	Designation of priority areas with strict exclusion of conflicting land uses on soils of medium and high productivity, which demand comprehensive case-by-case analysis at lower tiers and in municipalities' weighting process; Link designations for soil protection with specific quality criteria for the adaptation to climate change. Further adaptation options at project level: - technological developments (e.g. new crop varieties, adaptive capacity of genetically modified crops, innovations in water management) - farm production practices (e.g. crop diversification, irrigation) and - farm financial management and compensations.

5.4.3 LUCCA 10 – Soils to be Protected against Erosion

Climate change with increasing aridity particularly affecting large-scale farmlands in Eastern Europe (see chap. 3.3), will increase the risk of soil erosion, salinisation and degradation. Agricultural areas have to be consequently protected against loss of soil through erosion, if preventive measures of food security shall be undertaken with SEA-REP. Important measures at project level are for instance certain agricultural techniques, a permanent vegetation cover and wind breaks through plantations of hedgerows and trees. Beside these, regional planning should take over preventive responsibility to designate and remediate areas in risk of water and wind erosion of the soil. Regional areas, which are sensitive to soil erosion should be designated in REP and protected by measures for prevention of further soil loss.

Definition

The possibility of erosion of the soil, respectively the soil resistance, determines the shift of soil material at the soil surface through water, wind or gravitation. It is influenced from the soil type, the content of organic substance and the soil structure (LfUG 2001a). As soil erosion is mainly

tackled by cultivation measures of the agricultural sector at project level, the regional plan can only be assessed by RPB on its consideration of the current and future erosion risk of soils during the comparison of alternative sites for afforestation and other land use changes.

Regional Environmental Orientation Objectives

- identified areas at risk of organic matter decline (EC 2007a: 18);
- decreased loss of soil on arable land caused by erosion;
- restricted soil loss on arable land caused by erosion;
- strict protection of arable land on slopes against soil erosion;
- increased area share of extensively managed grassland at the total agricultural land in a region;
- afforested land with priority on soils, which are endangered by erosion.

Derivation of Environmental State and Impact Indicators

State indicators:

- arable areas with requirements for protection against water erosion (after fine soil types of the topsoil) according to the potential of erosion through water expressed in water erosion resistance;
- arable areas with requirements for protection against wind erosion according to the potential of erosion through wind expressed in wind erosion resistance.

Impact indicators:

- land use change on soils with inferior, general or superior importance for the protection against water and wind erosion in ha;
- change of water balance on soils with inferior, general or superior importance for the protection against water and wind erosion in ha.

Environmental Data Requirements

- maps on the erosion risk of soils under climate and land use change scenarios.

Assessment Thresholds and their Methodological Derivation

The state of the environment for LUCCA 10 was determined for the region OL-NS separately for the water erosion resistance (EfW) and wind erosion resistance (EfA) (table 38; Stratmann et al. 2007a). Extremely erodible through wind are soils, which are dominated by silt; loess soils being rich in fine sand; or sandy soils with mixed granular structure. Damage through water erosion in Saxony occurs on soils of medium to high affinity to siltation (soil types with a high share of silt and fine sand) depending on the organic substance in the upper soil layer, the wind speed close to the surface, the degree of moisture etc. (LfUG 2002, 2004). The erosion rate was calculated on the basis of the soil concept map and the digital morphology model according to the general equation for soil degradation (ABAG), which is a methodological basis for the estimation of soil erosion through water (Schwertmann et al. 1990). Roch defined a threshold for a high erosion risk on arable slopes of > 12 % for West Saxony (Roch 2000: 61), which can assist in estimating limit values of future risks under effects of heavy precipitation and high aridity with climate change.

Table 38: Assessment of the erosion risk

(Sources LfUG 2002, 2004a; Roch 2000: 61 for West Saxony; Staatsbetrieb Sachsenforst 2005)

(5) Special Importance:	High wind and water erosion risk: EfA 4 and 5 / EfW 4 and 5 (for OL-NS); Arable slopes > 12 % (for West Saxony).
(3) General Importance:	Moderate wind and water erosion risk: EfA 3 / EfW 3 (for OL-NS).
(1) Inferior Importance:	Low wind and water erosion risk: EfA 1 and 2 / EfW 1 and 2 (for OL-NS); Erosion protection forest.
EfW = Water erosion resistance EfA = Wind erosion resistance	

Classification of Conflict Intensity

The assessment of afforestation sites and further relevant designation zones of a regional plan aims at a prevention from loss of soil through erosion (table 39). Existent erosion protection forests are to be preserved. The proposals of the RPB for the afforestation on soils, which are endangered by

Table 39: Conflict intensity of LUCCA 10

Assessment of the environmental impacts on the individually affected area and impact zone (5) = Special importance, (3) = General importance, (1) = Inferior importance		
Conflict Intensity	**Effect of impact factors/impact indicators on the affected area and impact zone with importance according to the assessment of the environment**	
	Land Use Change	**Change of Water Balance**
1. High Conflict	5	
2. Medium Conflict	3	
3. Low Conflict	1	
Positive Environmental Impacts	Assessment in comparison of alternatives of site-specific REP contents: Designation of priority areas for afforestation on areas with high or medium erosion risk in the geographic context.	
Adaptation Measures	Target-oriented designation of priority areas for adaptation to climate change on arable land, which shall be converted to grass- or woodland; Setting a strict target for a maximum soil loss in the region caused by erosion of less than n t/(ha*a); Amending designation criteria for designation of priority areas for agriculture: e.g. on arable land on slopes < 10 %	
Tiering	Stricter implementation of adaptation measures for the prevention of soil erosion in agricultural planning under consideration of effects of climate change.	

erosion, and applied designation criteria shall be site-specifically evaluated with LUCCA 10 and in the overall strategic assessment. It has to be estimated, if land use change or a change of the groundwater level significantly increase or reduce the erosion risk on the affected areas and the erosion tendency in the region. Future adaptation measures have to be developed and implemented in cooperation with experts from agriculture and forestry.

REP has to integrate area-specific adaptation measures from the agricultural sector for the prevention of soil erosion and salinisation under climate change. A common framework shall be created by agricultural experts for priority areas for the selection of certain future crop types and technical cultivation measures on future areas to be in risk of erosion. Higher aridity and heavy precipitation events, supported by climate change, will call increasing attention on the development and protection of rural landscape elements, hedgerows, shrubs, balks and marginal strips as shelter of the soil and plants. Further reforms of the CAP on the extensification of agricultural land use are expected. Stricter objectives for the protection of soils in risk of erosion to be integrated into REP designations such as priority areas for agriculture will be required.

5.4.4 LUCCA 11 – Freshwater Resources with Potential for Water Storage and Supply

The EC Water Framework Directive (WFD) aims at the protection of European water bodies and groundwater against deterioration and pollution and to achieve and maintain existent good water status or good ecological potential. River bed regulations and water abstraction of the past had far-reaching impacts on aquatic ecosystems and their catchment areas. Some modified water courses in heavily populated areas might be impossible to restore to natural conditions (Nixdorf et al. 2008: 302). The water availability of freshwater bodies and groundwater protection areas in certain regions of the EU will decrease with increased evaporation resulting from average higher aridity of the air and bare soils, decreased precipitation quantity and frequency as well as decreased leakage water quantities, which will intensify with climate change particularly in Southern Europe (see chap. 3.3).

Definition

LUCCA 11 combines essential freshwater bodies, wetlands and groundwater resources with potential for future water storage and supply. These functions will gain increasing importance for humankind in a changing climate, as access to and allocation of safe drinking, irrigation and bathing water in a region must be maintained. A focus is put on the quantitative protection of water against water level change in a region; the achievement of a good chemical and biological water quality (water quality class II, LAWA 1998) is a strict objective of the WFD, whose national and regional level of compliance must generally be assessed in SEA. Restrictions are legally-binding pollution standards and objectives of the EC Groundwater and WFD, implemented in national drinking water regulations and River Basin Management Plans.

Regional Environmental Orientation Objectives

- ensured adequate future water supply and demand management through designation of water reservoirs (CCW et al. 2004b: 6);

- protected water quantity of surface waters (rivers and lakes) in their catchment areas;
- safeguarded and maintained groundwater development rates and levels, and the connectivity of regional groundwater aquifers;
- integrated framework for adaptation measures from agriculture for the removal of agricultural drainage systems and additional reservoirs for water at lower project level (EA 2006a, 2006b).

Derivation of Environmental State and Impact Indicators

State indicators:

- regional water bodies with future potential for water storage and supply under spatial effects of climate change (first and second category waters);
- land uses with future potential of groundwater development;
- land uses with future potential of a remediation of the water regime (third category waters).

Impact indicators:

- land consumption of land uses of special, general and inferior potential for freshwater storage and supply on the affected area in ha or km^2;
- land use change of land uses of special, general and inferior potential for freshwater storage and supply on the affected area in ha or km^2;
- fragmentation of land uses of special, general and inferior potential for freshwater storage and supply on the affected area in km and rest area share in %;
- change of water balance land uses of special, general and inferior potential for freshwater storage and supply on the affected area and impact zone in ha or km^2.

Environmental Data Requirements

- geological and hydrological maps;
- land use and biotope type mapping;
- mapping of vulnerability of water resources under climate change effects and according to objectives of the Water Framework Directive.

Assessment Thresholds and their Methodological Derivation

The aim is an assessment of the future potential for water storage and supply of regional water bodies and wet biotopes (first and second category waters). Geologists and hydrologists will have to provide regional spatial data on the future potential of regional primary and secondary category water bodies to supply and store water under a changed climate in cooperation with climatologists and geologists (table 40).

Predictions for water inflow through precipitation and inundation, water loss through evaporation and transpiration, and the relation between area of catchment to lake volume, lake surface area, the mean depth of the lake and residence time are possible components of vulnerability assessments in the different geographic European regions. Typologies of water bodies and assessments in the course of the compliance with objectives of the WFD (Nixdorf et al. 2008: 308) create an essential fundament for the assessment of the regional reservoir storage vulnerability under climate change conditions. It was estimated that particularly important will be water bodies of a minimum catchment size and a high average discharge, transnational rivers and small recharging water types

Table 40: Estimated regional reservoir storage vulnerability under climate change conditions

(5) Special Importance	Low regional reservoir storage vulnerability under climate change conditions: National primary and secondary water bodies with future potential for water storage and supply; Regional water bodies of a high catchment size and a high average discharge; Regional small, but in the future recharging, water types with a high water quality; Areas with a future high groundwater development rate in > 200 mm/a (LfUG 2004, 2006 for OL-NS); Fresh or ground water sanitation areas.
(3) General Importance	Medium regional reservoir storage vulnerability under climate change conditions: Drinking water protection site zone III; Regional water bodies of a medium catchment size and a medium average discharge; Areas with third category water bodies with future potential for a remediation of the groundwater regime; Areas with a future medium groundwater development rate in 101-200 mm/a (for OL-NS).
(1) Inferior Importance	High regional reservoir storage vulnerability under climate change conditions: Water bodies without future potential for water supply and storage (e.g. very shallow lowland lakes with small catchment area, without afflux or exchange with groundwater in regions affected by a high precipitation decrease); Land uses without potential of a remediation of the groundwater regime; Areas with a future low groundwater development rate in ≤ 100 mm/a (for OL-NS).

with a high water quality. In Germany a consideration of water bodies above area sizes of 0.5 ha can be suggested for SEA-REP (PGW 2002: 18).

The terrestrial water balance in a region can additionally be assessed with the groundwater development rate (Voigt et al. 2004), which will be area-specifically influenced by effects of climate change. Therefore SEA-REP will also require data on the future groundwater development rate in a region, taking forecasted conditions of water, soil and climate into consideration. The current state of the groundwater development rate in OL-NS was assessed in three classes: high: > 200 mm/a; medium: 101-200 mm/a; low: ≤ 100 mm/a (LfUG 2004b, 2006). The average precipitation rate in Eastern Germany is low in comparison to Western German regions with rates > 600 mm/a. The groundwater development rate describes the current „*capacity of the landscape regime to regenerate groundwater occurrences due to the vegetation structure, climatic conditions, permeable cover layers and relief*" (Marks et al. 1992: 35). The threshold values for the existent groundwater development rate applied in transSEA will have to be revised and adapted to increasing arid conditions in this region.

A third assessment of the potential of the remediation of the water regime of degraded wetlands and land uses under the influence of third category waters is recommended. Third category water bodies are defined as brooks and ditches, often drained for agricultural and forestry land use.

Lane et al. (1999) propose to aggregate a regional index on 'regional reservoir storage vulnerability', which includes the effectiveness of regional supply systems to meet demands. For this purpose a regional specific assessment of the sensitivity of current groundwater and drinking

water catchment areas is required. A simplified way to achieve results of environmental conflicts with water storage and retention areas is to categorise standard land uses or biotope types according to their future potential for water storage and supply. A future time point of a certain status of the state of environment on the affected area as influenced by climate change must be determined. Regional-specific targets for the protection of water resources will have to be identified. Designations of freshwaters, groundwater zones and wet biotopes of superior importance for water storage and supply should be integrated into regional planning.

Classification of Conflict Intensity

The conflict intensity must be determined for each assessment parameter above under consideration of expert data and site-specific case-by-case assumptions for changes of the state of environment with effects of climate change. Table 41 presents a possible conflict classification, adaptation measures and tiering tasks.

Table 41: Conflict Intensity of LUCCA 11

Assessment of the environmental impacts on the individually affected area and impact zone (5) = Special importance, (3) = General importance, (1) = Inferior importance			
Conflict Intensity	**Effect of impact factors/impact indicators on the affected area/impact zone with importance according to the assessment of the reservoir storage vulnerability**		
	Land Consumption	**Land Use Change**	**Change of Water Balance**
1. High Conflict	5, 3	5	5, 3
2. Medium Conflict	1	3	1
3. Low Conflict	–	1	–
Positive Environmental Impacts	Assessment in comparison of alternatives of site-specific REP contents: Designation of flood protection areas.		
Adaptation measures	Designation of priority areas of lakes for prohibited diversion of water without augmented flow due to risks of long-term reductions in lake water levels; Designation of regional freshwater sources as priority areas of water reservoirs with low vulnerability to climate change and high future potential for water storage and supply; Designation of land uses of future high groundwater development as priority areas for groundwater protection; Designation of agricultural land as priority areas for the remediation of the groundwater regime and the removal of agricultural drainage systems with the objective of an increase of groundwater levels; Designation of freshwater and groundwater sanitation areas.		
Tiering	Detailed estimation of the future potential of local water bodies for water storage and supply; Technical solutions for water capture from precipitation and storage in reservoirs, cisterns or tanks as a reserve for annual periods of high aridity.		

In a first step, a regional decision support system for the vulnerability and potential of regional water bodies and biotopes as long-term freshwater resources under effects of climate change should be developed by experts of the water sector and landscape planning. For this purpose regional water regime simulations, differenciated for specific areas, must be developed. These create a basis for adaptation measures of remediation of drainages on agricultural and forest areas. In cooperation with agricultural and forestry sector priority areas shall be identified for the increase of the infiltration and reduction of the water erosion linked to adapted cultivation and management of the land (ARL 2003: 14).

5.4.5 LUCCA 12 – Land Uses with Potential for Retention and Absorption of Precipitation and Inundation Water

A tendency in the EU is a decrease in the area of natural land of wet grassland and wetlands, mainly due to agricultural drainage, urban sprawl, coastal development, river engineering works and other artificial land use developments (EEA 2005a). As climate change potentially leads to heavy precipitation events and temporary increase of inundation water in parts of the European regions (see chap. 3.3), land use with functions for water retention and absorption will gain importance in the future. The objective is to provide adequate flood prevention along rivers by safeguarding areas for the retention and storage of precipitation and inundation water. Designations at regional plan level will have to be accompanied by technical flood prevention measures at project level. New soil sealing on areas of high importance for retention such as floodplains cannot be recommended. Regional planning should set a stricter framework for restrictions and additional surveys at lower land use planning level.

Definition

Land uses with potential for retention and absorption of precipitation and inundation water are relevant for the prevention of floods and danger of human being, particularly in coastal zones and floodplains along regulated watercourses. Floodplains can be open spaces between river shores and dykes, flood protection areas or retention areas, which were designated and preserved by the competent water body. Beside the naturality of a river course, the level of the retention ability of flooded land uses is an essential factor for the estimation of the significance and spatial and time scope of floods.

LUCCA 12 represents land uses with a potential for a share of the water to remain in the landscape. This requires specific research on flood protection, water management and groundwater development in a region. Criteria of the assessment are the level of surface run-off, infiltration, leaching and evaporation and transpiration. These parameters are linked to the characteristics of the soil surface: if this is sealed or permeable for water and if vegetated, which type of vegetation cover occurs (Borgwardt 1994; Eppel 1996).

Regional Environmental Orientation Objectives

- natural floodplains safeguarded from all building activities;
- integrated current knowledge on effects of climate change on river flows in infrastructure design (EC 2007a: 19);

- used natural processes to the maximum to reduce flood risks e.g. working with wetlands, maximising retention capacities at source, sustainable land use and spatial planning limiting exposure and vulnerability (EC 2007a: 17);
- prohibited construction on floodplains in unspoiled riverside landscapes (SMUR 1997: 5, 7);
- ensured that retention areas can cope with changing rainfall patterns and intensity (CCW et al. 2004b: 6);
- applied precautionary and risk-based approach to soil sealing in floodplains (CCW et al. 2004b: 6);
- preserved land uses of high importance for flooding and water retention, i. e. surface waters and their natural floodplains, biotope or vegetation types with low water runoff;
- preserved land uses of high importance for water storage, i. e. water catchment areas, unsealed areas and surface waters;
- safeguarded use of water bodies (for fishery, recreation, water energy, extraction of drinking water) whilst considering flood prevention, as long as avoidable impacts of their ecological functions are refrained from;
- integrated mitigation zones for remediation of regulated river sections with concrete banks as recommended in water management sector.

Derivation of State and Impact Indicators

State indicator:

- designated floodplains and retention zones;
- natural river sections (water quality I-II);
- absorption capacity of water bodies and reservoirs;
- evaporation and transpiration rates of land uses;
- retention ability of land uses.

Impact indicators:

- land consumption of areas of special, general and inferior importance for retention and absorption of precipitation and inundation water on the affected area in km² or ha;
- land use change of areas of special, general and inferior importance for retention and absorption of precipitation and inundation water on the affected area in km² or ha;
- change of water balance affecting areas of special, general and inferior importance for retention and absorption of precipitation and inundation water on the affected area and impact zone in km² or ha;
- directed flooding of areas of special, general and inferior importance for retention and absorption of precipitation and inundation water on the affected area and impact zone in km² or ha.

Environmental Data Requirements

- maps with rivers, floodplains and designated flood control areas;
- flood risk modelling and scenarios;
- maps on soil sealing level and retention ability of land uses.

Assessment Thresholds and their Methodological Derivation

a) Assessment of the absorption capacity of water reservoirs, their retention areas and floodplains

Water reservoirs and their retention areas and floodplains can be assessed on their capacity for

water absorption in new conditions under climate change (table 42). This capacity will depend on factors such as the catchment area, the water volume, inflow and outflow and temporary fluctuations of the water level of the water body. A regional classification in at least three classes of a high, moderate and low capacity has to be carried out by experts.

Table 42: Assessment of the absorption capacity of water reservoirs and their retention areas and floodplains

(5) Superior Importance	High absorption capacity of water reservoirs, retention areas and floodplains.
(3) General Importance	Medium absorption capacity of water reservoirs, retention areas and floodplains.
(1) Inferior Importance	Low absorption capacity of water reservoirs, retention areas and floodplains.

b) Assessment of the absorption capacity of other land uses

Land uses of importance for retention and absorption of precipitation and inundation water can be estimated after the parameters of the evaporation and transpiration rates of land use types, the retention ability of vegetation types/soils and the absorption capacity of water reservoirs, retention areas and floodplains (table 43).

Table 43: Assessment of the evaporation and transpiration rates of land use types

(Source: Henz 1998).

(5) Special Importance:	Low evaporation and transpiration rates of land use types: Areas with permanent connected vegetation cover and temporary up to permanent evaporation and transpiration; Grassland; meadows; extensively used pastures; gardens; scrubland; orchards; wetlands; woodlands, open water bodies.
(3) General Importance:	Medium evaporation and transpiration rates of land use types: Areas without surface run-off: open soils, gravel etc.; Areas without surface run-off with low vegetation development; Temporary vegetation covered open soils: arable land; dry meadows; pastures with partly open soils.
(1) Inferior Importance:	High evaporation and transpiration rates of land use types: Sealed soils > 50 %; Partly permeable surfaces on slopes > 5 %.

Henz (1998) assessed the evaporation and transpiration rates of land use types. The class of ‘100 % permanent connected vegetation cover’ ensures an at least low permanent evaporation and transpiration. The transpiration rate of woodlands was estimated as the highest, as these contribute the most to summer precipitation and prevention of soil erosion.

c) Assessment of the retention capacity of vegetation types and soils

Another part of LUCCA 12 can be a regional assessment of the retention ability of vegetation types and soils. Kraetzschmer (1995) used the criteria of slope, groundwater level below ground, vegetation cover and soil sealing grade for the assessment of the retention ability (table 44). The soil permeability is only considered with the vegetation cover including land use and management. A more specific assessment of the retention ability at local planning level is needed, as this assessment at the higher regional planning level cannot pay enough attention to steep slopes and compacted soils, which do not effectively function as retention areas.

Table 44: Assessment of the retention ability of vegetation types and soils

(Source: Kraetzschmer 1995, Tab. 4, p. 74)

(5) Superior Importance	High retention ability of vegetation types and soils: - Groundwater (Gw) level below ground > 1,5 and slope ≤ 3 %; - Gw level below ground > 1,5 m and slope ≤ 3 % in open spaces and gardens or slope > 3 % in forests and shrubland; - Gw level below ground 0,8-1,5 m and slope ≤ 3 % in forests and scrubland.
(3) General Importance	Medium retention ability of vegetation types and soils: - Gw level below ground > 1,5 m and slope > 3 % in open spaces and gardens; - Gw level below ground 0,8-1,5 m and slope ≤ 3 % or > 3 % in open areas and gardens; - Gw level below ground < 0,8 m and slope ≤ 3 % or > 3 % in forests and scrubland; - Gw level below ground < 0,8 m and slope ≤ 3 % in open spaces and gardens.
(1) Inferior Importance	Low retention ability of vegetation types and soils: - Gw level below ground < 0,8 m and slope > 3 % in open spaces and gardens; - Gw level below ground > 1,5 m ≤ 3 % or > 3 % in urban areas with soil sealing < 50 %, stockyard; - Gw level below ground 0,8-1,5 m ≤ 3 % or > 3 % in urban areas with soil sealing < 50 %, stockyard; - Gw level below ground < 0,8 m ≤ 3 % or > 3 % in urban and transport areas with soil sealing < 50 %; - Urban and transport areas with soil sealing > 50 %.

The classes of the assessments in tables 42-44 were summarised to three classes of the potential for retention and absorption of precipitation and inundation water of regional land use types (see table 45). The respective highest class of importance of a land use influences the overall classification. This theoretical summary must be revised on the basis of regional environmental data, expert knowledge and specific conditions of the environment.

Table 45: Estimated land uses with potential for retention and absorption of precipitation and inundation water

(5) Superior importance	Water bodies, floodplains and other land uses of international and national importance: - designated floodplains and retention areas; - natural river sections (water quality I-II); - low evaporation and transpiration rate of land use types; - high retention ability of vegetation types and soils; - high absorption capacity of water reservoirs, retention areas and floodplains.
(3) General importance	Water bodies, floodplains and other land uses of sub-regional and regional importance: - medium evaporation and transpiration rate of land use types; - medium retention ability of vegetation types and soils; - medium absorption capacity of water reservoirs, retention areas and floodplains.
(1) Inferior importance	Water bodies, floodplains and other land uses with future potential: - high evaporation and transpiration rate of land use types; - low retention ability of vegetation types and soils; - low absorption capacity of water reservoirs, retention areas and floodplains.

Classification of Conflict Intensity

The conflict intensity of REP impacts affecting the importance of the potential for evaporation and transpiration, retention and absorption of precipitation and inundation water on the affected area must be operationalised for each European region and area-specific simulations of impacts of climate change on the water regime.

Predictions of more frequent and heavy precipitation intensified by climate change require a revision of current assessments of retention and flood zones of European watercourses. For example in a review of flood defences in the UK, the EA (2006c) found that a tenth of the population in England and Wales now lives on floodplains. Resurvey of mapped floodplains is under way, as current maps do not accurately reflect future vulnerability. The derivation of regional risk maps with areas of high, medium and low danger to be flooded in the future is useful. Boundaries of natural floodplains shall be identified as flood risk areas in consultation with geology and water management and designated as priority areas for preventive flood protection as recommended by ARL (2003: 14). With such maps taboo zones for housing development and areas to be target-oriented flooded can be designated in REP aiming at a prevention of other more sensitive areas from flooding. Interim targets for the development of updated maps should be set for the regional plan level.

Table 46: Conflict intensity of LUCCA 12

Assessment of the environmental impacts on the individually affected area and impact zone (5) = Special importance, (3) = General importance, (1) = Inferior importance				
Conflict Intensity	**Effect of impact factors/impact indicators on the affected area and impact zone with importance according to the assessment of the environment**			
	Land Consumption	**Land Use Change**	**Change of Water Balance***	**Directed Flooding#**
1. High Conflict	5, 3	5	5	1
2. Medium Conflict	-	3	3	3
3. Low Conflict	1	1	1 (*Long-term raised groundwater level)	5 (#temporary)
Positive Environmental Impacts	Assessment in comparison of alternatives of site-specific REP contents: Directed flooding of areas for instance with the designation of priority or reserve areas for technical flood prevention and potential flood development areas, remediation of rivers and streams, relocation of ditches etc.			
Mitigation and Adaptation Measures	Identification of boundaries of natural floodplains as flood risk areas in consultation with geology and water management and designation as priority areas for preventive flood protection (ARL 2003: 14); Designation of priority areas to be flooded in cases of high quantity of inundation water; Designation of priority areas for groundwater sanitation; Designation of priority areas for surface water remediation; Designation of priority areas for land use types with superior importance of their potential for retention and absorption, e.g. in areas of low urban population density, which are allowed to flood temporarily.			
Tiering	Designated areas of natural floodplains, which shall be safeguarded from all building activities, shall be further classified at lower land use planning level according to the level of risk (UVP Gesellschaft 2000: 6). Creating a framework for classification of designated flood control areas according to the level of risk at lower land use planning level; In areas of medium importance for water retention and absorption at regional plan level more detailed surveys shall be carried out and requirements shall be set for mitigation of effects of climate change at lower land use planning and project EIA tiers.			

6. Conclusions and Recommendations

6.1 Conclusions

One of the hypotheses of this research was, that an indicator system with indicators and assessment thresholds can be developed, which operationalises climate change adaptation policy and integrates adverse effects of climate change into SEA-REP. The SEA-REP assessment method and indicator system developed in the INTERREG project transSEA for the Saxon region Upper Lusatia-Lower Silesia was therefore analysed for a more transparent integration of objectives for the protection of the global climate and adaptation to future effects. The EU and German policy for environmental land protection, the mitigation of greenhouse gas emissions and adaptation to climate change effects, as well as currently predicted spatial effects of climate change in Europe motivated the selection of the indicators LUCCA 1-12. These measure environmental potentials of the state of environment in a region, which will be increasingly important for the prevention of high conflicts and the anticipatory adaptation of land use to climate change. During regional plan-making cumulative effects of all regional developments with effects of climate change should be considered in an overall strategic assessment. The national climate and land protection policies of the EU Member States and forecasted regional spatial effects will have to be operationalised with regional environmental objectives and assessment thresholds. LUCCA 1-12 represent a standardised guidance with examples for the derivation of assessment values.

The SEA-REP indicator system and LUCCA module allow a systematic assessment process, which can be integrated into conventional regional plan-making. The consequent application of the indicators LUCCA 1-12 and generation of conflict maps will make site-specific environmental conflict intensities of regional plan designations transparent. The comparison of alternative sites and implementation of mitigation measures can directly address conflicts with adaptation to climate change. A ranking of potentials of land uses for adaptation will assist in priority setting of regional activities and use of financial resources.

Whether the central research questions were answered in this study shall be concluded and discussed in the following.

Which indicators and thresholds can be applied as methods for the identification, description and assessment of environmental impacts of regional land use planning designations combined with effects of climate change?

The developed indicator system of LUCCA 1-12 represents a first important systematic planning, decision-making and assessment basis for SEA-REP. The indicator catalogue may function as an orientation checklist for the RPB for an evaluation of the status and progress of spatial adaptation to climate change. SEA-REP can potentially become a useful tool to enhance regional conservation in changing environments, complementary to and consistent with already existing management instruments and new future instruments. The system includes the central elements of SEA of impact and state indicators, environmental objectives and assessment thresholds, which have to be regionalised for each specific EU region in case-by-case-approaches. Special attention was given to environmental precaution and future degradation or loss of land uses with importance for adaptation to climate change and a mitigation of negative impacts of climate change. The indicators are clearly defined units of measurement of potential impacts of REP contents and climate change on the land use. They can be used to quantify

future physical degradation or loss of LUCCA, a fact, which widens the distance to the achievement of climate adaptation targets.

How can environmental quality objectives and environmental quality standards for the adaptation of land use and resources to climate change be operationalised at the regional planning level?

The analysis of existent environmental policy showed, that land degradation requires more attention in the course of a progressive adaptation to climate change. Regional environmental orientation objectives were derived from existent environmental objectives and standards. The conclusion is a still existing need for the improvement of the operationalisation of national objectives at regional planning level. RPB are challenged to actively contribute to stricter target-setting and the implementation of adequate measures.

What are benefits of the SEA-REP process as an instrument for improved protection of land and resources against degradation, an adaptation of regional land use to climate change and the mitigation of adverse effects on the environment?

SEA-REP has the potential to function as a trigger and information tool on the way towards preventive and environmentally sound regional developments. Challenges are that all interests of the sector planning have to be equally balanced, that there exists an implementation deficit of legally-binding environmental objectives at regional level and that the political willingness for a stronger shift towards more environmentally-sound development must be further strengthened. Traditional land use conflicts will play a less important role in the future than sustainable area management. Without integration of effects of climate change into regional planning, land consumption and physical degradation of valuable land and resources, as well as accumulations of impacts of REP and climate change will not be sufficiently evaluated and mitigation measures will not be implemented nor will the political effort be made transparent for the public.

Strengths

The major strength of this indicator-based approach is a systematic SEA-REP module directly linked to the existing plan-making process. Indicators and assessment thresholds make the state of art of EU regions' achievements concerning adaptation to climate change transparent and understandable. The system is flexible enough to react on regional plan optimisation and change, as well as new findings and data on impacts of climate change on existent and planned regional land uses. LUCCA can be directly integrated into the procedural management of SEA-REP. With increasing scientific knowledge on impacts of climate change on the EU regions, the LUCCA indicator system should be revised and adapted. The objective in the future will be a regional sustainable area management, which integrates concerns and benefits of climate change. For this purpose regional environmental objective concepts are required, which integrate requirements from sector planning for adaptation.

With an optimistic view on an efficient implementation of SEA-REP in the EU regions, the regions will move one step forward in their adaptation to climate change. The indicator system also has the potential to motivate EU regions to specifically consider concerns of climate change in their decision-making, and thus, create a fruitful competition for a future high living quality and sustainable development. This effect could be promoted with financial incentives and awards.

With a clear and complete documentation in the environmental report in the future the public will get the

chance to understand the current status of the regional environmental potentials, vulnerabilities, adaptive capacities and preventive strategies. SEA-REP is therefore considered as an adequate instrument for the progressive raising of the public awareness on core environmental problems of planning for land use change lying ahead in the EU regions. An improved public awareness of the necessity and urgency of actions and improved communication and cooperation with neighbouring EU regions on a common basis of SEA-REP and future changes caused by global warming will be a major accomplishment. If the formulation of common strategies for adaptation to climate change, e.g. for prevention from flooding caused by heavy precipitation events, secure drinking water concepts, provision of recreational and fresh air areas and natural disaster management etc., is successful, negative impacts of climate change will be easier to mitigate and natural disasters will be better dealt with. The promotion of public involvement and awareness with SEA-REP will increase the acceptance of the public for measures for prevention of disasters caused by climate change. These cannot only be financial or based on technical solutions, but will have to include a certain change of human behaviour in the long-term. With increasing knowledge, education and mobility, more inhabitants of the regions will select where to live and work in the EU. They will most likely choose the most sustainable regions with a high living quality. In the long term these might be the EU regions with a high level of integration of environmental and human health concerns into decision-making and the most flexible adaptation to climate change.

Weaknesses

Major Weaknesses of the LUCCA indicator system may be that data gathering is needed, if current environmental data sets are small. Without a comprehensive information system, the application of the quantitative indicators is feeble. The process of data surveys and derivation of assessment thresholds could slow down the SEA-REP process. At the same time the number of indicators and aggregations are rather complex. It has to be tested in practice, if a simpler qualitative method may be more appropriate instead of a complex quantitative method. With this SEA-REP approach cause-effect-relations cannot be presented in their complexity, but additional qualitative assumptions will always stay necessary. The process and contents of the assessment of cumulative effects need special attention, which was not investigated in detail in the scope of this research.

Moreover scientific requirements of the concept could conflict with its applicability in practice. Particularly during the site-specific assessment a high number of alternative sites (e.g. over 100 alternative mining sites) could mean an excessive demand of effort for the RPB. In such cases the actual purpose of SEA and the strategic level of regional planning should be kept in mind: to optimise the regional plan and to adequately consider environmental concerns including impacts of global climate change. Consequently the process of mitigating negative impacts itself and tiering becomes more important than each individual site-specific result of the environmental conflict analysis.

The regional operationalisation of indicators and assessment thresholds does not directly allow a comparison of the results for individual LUCCA in different EU regions. However, a common evaluation of the efficiency of the tool is feasible with the comparison of distance-to-targets for adaptation to climate change.

Opportunities

Regional land use planning is an adequate level for prevention and mitigation of negative impacts of

physical degradation, affecting land uses of importance for adaptation to climate change, as it can work towards setting more consequent priorities of land use change. Comprehensive land use planning can better assess cumulative impacts with effects of climate change than sectors, as it cross-sectoral looks at all land uses in a region. The actual damage of climate change will be mitigated with adaptation, if:

- spatial climate change effects can be predicted;
- the change does not exceed a certain level;
- adaptation measures can and are implemented.

With the aim of using SEA-REP as a comprehensive early-warning system for the adaptation of EU regions to climate change, further modules beside LUCCA can be developed for the integration of climate change into land use and sector planning. These could for instance put a special emphasis on the assessment and mitigation of:

- cumulative and synergic impacts of climate change and REP designations;
- social impacts of climate change and REP designations;
- impacts of diseases related to climate change on human health;
- impacts of regional plan designations for renewable energy production (offshore wind energy production, wind energy production in forests, biomass production with woody corps etc.) on LUCCA;
- impacts of natural disasters, hazards, storms, high tide caused by climate change and their conflicts with REP designations;
- economic impacts and their links to economic instruments.

Threats

However, from a more pessimistic point of view, new challenges and problems are lying ahead and methods and strategies are still missing on how to prevent and react on environmental changes directly and indirectly caused by climate change. The time span of their occurrence and the significance of impacts are still uncertain. A lot of research is needed on the assessment of cumulative and synergic impacts, which will be influenced by changing natural conditions. The complexity of the interrelations of all environmental media in the context of changing systems due to climate change will never be completely understood. For instance large-scale flood events might more frequently and more intensively occur in the future than predictable. However, it is a fact that the reduction of land consumption needs to be stronger integrated into regional area management. At the same time SEA-REP should not be seen as an impediment of economic development. Scepticism of SEA-REP potential positive effect on an area-wide 'ecologisation' may arise. One concern is that the SEA Directive will mainly introduce an improved transparency of traditional regional planning decisions with public participation and new monitoring concepts, but hardly any new changes of land uses in the regions.

6.2 Recommendations

The main tasks of the national and regional spatial planning bodies for an adaptation of regional land use to effects of climate change are given in the following. These are meant as a first guidance for the implementation of the LUCCA module in the course of a SEA-REP process. Reasons for non-compliance with minimum requirements of protection of the land and resources against further physical degradation should be well justified and documented in the environmental report. The recommendations are not

exhaustive and will have to be amended with the practical application of the proposed indicators, increasing knowledge gain on spatial effects of climate change and future developments of regional land use. The following overall recommendations can be formulated for the national and regional decision-making levels:

1. the progressive physical degradation of land and natural resources needs to be stricter, and consequently mitigated at the regional scale;
2. binding environmental quality standards for the protection of the land and resources against degradation with the aim to restrict the average global temperature increase to 2°C should be set;
3. land uses of importance for adaptation to climate change or with potential for mitigation of carbon or water release should be more strongly weighted in regional planning;
4. institutional responsibilities and activities at different planning levels for analysis and supply of information and data on spatial effects of climate change, potentials and vulnerabilities of the environmental components and the formulation of adaptation strategies should, as soon as possible, be precisely clarified;
5. the cross-sectoral cooperation between land use planning and sector planning should be further improved for the development of common strategies for adaptation of land use to climate change;
6. strategic environmental assessment should contribute to an improved public participation in regional planning visions and target setting for adaptation of land use to climate change and mitigation of greenhouse gas emissions by land use change.

6.2.1 Recommendations for National/Federal Competent Ministries

An increasing influence of the EU level on legislations at national level contributes to a harmonisation of living conditions in all EU Member States. With the objective of keeping the future quality of life as high as possible, the EU countries should continue to implement national environmental protection and climate adaptation strategies at all planning levels and in all sectors to prevent from further degradation of the land and natural resources. Responses to forecasted spatial effects and environmental conflicts of regional development and climate change are revised national policies for land use change. The SEA-REP indicator system is considered as a suitable instrument to promote the implementation of EU and national environmental climate policy at regional scale. The proposed indicators and assessment thresholds are directly linked to existent EU, national and federal environmental objectives and standards (top down). Lessons learnt from SEA-REP application can therefore also challenge national spatial and environmental policy (bottom up).

Integrating Substantial Standards

The first recommendation for policy makers is to integrate objectives and substantial standards for mitigation of and adaptation to effects of climate change into national environmental assessment legislations. The EC SEA Directive does not integrate substantial standards of the EC climate change policy, yet. Germany released its Climate Protection Programme, but as well did no create a compulsory link of climate change mitigation and adaptation objectives to environmental assessments in the EIA Act or land use planning in the Spatial Planning Act until spring 2008. Under recognition of a crucial future influence of SEA on target-oriented land use change, it is recommended to the competent German ministries to integrate minimum substantial standards of mitigation and adaptation into the national environmental assessment and spatial planning legislations. It should be clarified that the environmental media 'climate' – traditionally considered in EIA as local climatic condition – must gain more weight

with the assessment of impacts on the global climate and its effects. For instance the release of the planned German environmental code and national adaptation strategy of the Ministry of Environment will be essential responses.

Setting Standards

One possible method to finally reverse the ongoing trend of land consumption in Germany is to set binding limit standards to protect the land and natural resources against endless physical degradation. Beyond the existent environmental target for reduction of land consumption to 30 hectares per day by the year 2020 a strict legally-binding limit standard for new soil sealing should be set. Particularly land uses of importance for the adaptation to climate change (LUCCA) will have to be more protected against ongoing physical degradation, if a proactive prevention of further harm shall be prioritised. As the carrying capacity of a country or region concerning its sealed area share cannot be determined, a preventive no-action option is required.

The EU areas strictly protected after EC Habitat and Wild Birds Directive are an essential milestone for a provision of natural areas as habitats, refugia and migration corridors for fauna and flora and as areas with important functions for fresh air, water storage and soil protection. These areas have to be maintained, extended and the protection objectives defined in their management plans have to be amended in the context of changed soil conditions, vegetation cover and species composition. Particularly European open landscapes, which are permanently endangered by urban sprawl, need to be assessed on their potential for adaptation to climate change and their natural and recreational use for humans. Accordingly binding standards for the strict protection of LUCCA with superior national importance should be released. For instance green areas in the peripheries of large cities of current superior importance for recreation and fresh air exchange, or with a high future potential should legally and strictly be protected against urban sprawl. Another example is the strict protection of agricultural soils of national high productivity against any negative impact.

However, the setting of strict environmental standards is a political decision, which is based on different interests and concerns, and therefore faces various hindrances or difficulties. It thus can be a long and slow process. A faster recommended action is first of all to determine clear responsibilities and activities for adaptation measures at all planning levels.

Determining Clear Responsibilities and Activities at all Planning Levels

At national level clear future responsibilities and activities for adaptation to climate change should be determined. The RPB should be very aware of their essential task to specify and operationalise their planning frameworks according to objectives of environmental precaution and mitigation of physical degradation for lower binding land use planning tiers. Also the horizontal cooperation network of land use planners and sector planners should be further improved. SEA-REP is considered as an adequate instrument at regional planning level to initiate platforms for information exchange between different concerned environmental actors and pressure groups. Beside a clear dedication of responsibilities of current institutions for strategic leadership in formal instruments for adaptation to climate change, informal methods of regional cooperation will have to be further manifested.

Releasing Guidance for Good Land Use Planning Practice

Guidance for good regional planning practice under climate change should be developed, which include common transborder adaptation visions or cooperation concepts for strategies on water retention and storage, flood prevention and hazard management. Ideally regions facing common spatial effects of climate change define non-binding rules of future good planning practice for adaptation to climate change, the mitigation and monitoring of negative effects of climate change and the implementation of adaptation measures at all planning tiers. The LUCCA indicators represent a first module for a guidance for regional planning bodies for the development of a quantitative assessment method for SEA-REP.

An international exchange of knowledge and experience, will in the long-term, improve the transparency and raise public awareness on risks and potentials of each state's region, based on the need to adapt to climate change. Thus an essential task of the competent spatial planning body is to develop a national SEA guidance, which addresses the contents of the environmental report and proposes effective methods for the integration of objectives for the mitigation of carbon release and adaptation to climate change. Already existent national guidance should be amended through a chapter on the role of SEA for decision-aiding in adaptation of land uses to climate change.

6.2.2 Recommendations for Regional Planning Bodies

The relatively weak German regional planning does not sufficiently provide strict designations for area-wide protection of land and natural resources and their adaptation to climate change. Consequently all sectors, particularly agriculture and forestry, will have to formulate and deliver requirements in a common effort. However, sector planning – and especially landscape planning – cannot be responsible on their own for the integration of environmental concerns of climate change, but regional planners, preparing the comprehensive spatial instrument of a regional plan, should take over central coordination and mediation functions. A regional vision and regional plan designations hold a strong responsibility for the well-being of the population and the implementation of a preventive and sustainable land and resource management. For this purpose regional decision-making for an adaptive area management should be strengthened with the help of SEA-REP+LUCCA, combined with further formal or informal instruments.

An adequate weight of ecological concerns in the balancing process demands that all ecological consequences of the regional plan are analysed, and presented in a way which ensures that the decision makers are aware of the implications of their decision from an ecological point of view. This includes the time horizon of the decision. The decision-making process should be made transparent and understandable for the concerned, so that exertion of influence or even manipulations are prevented, which could lead to preventing an improper weighting. The operationalisation of national environmental objectives at regional scale should be made transparent.

Establishing Regional Environmental Objective Concepts for SEA-REP

SEA-REP can always only be as efficient as the available regional environmental quality concept. If for instance a regional objective for the adaptation of land use to climate change is still missing, SEA-REP cannot be effectively used to assess the distance-to-target of the contents of a regional land use plan from such an objective. The operationalisation of spatially-relevant national objectives should therefore be documented in a regional environmental objective concept for SEA-REP. Objectives should be further categorised on the basis of their relevance for the regional scale and level of legal liability. The RPB

ideally responds to a current lack of operationalised national objectives by determining its own regional orientation objectives for adaptation to climate change. Ideal regional environmental objectives represent values set by a society, which is aware of environmental problems and personal consequences of climate change. The RPB should involve transborder regional planners, experts from different sectors and stakeholders into the establishment of a revised regional environmental objective concept for spatial decision-making and monitoring.

Up-dating National and Regional Environmental Data Profiles

The EU Member States should support the efficient implementation of SEA-REP with the development and amendment of their national area-wide digital environmental information systems linked to EU spatial analysis. Particularly a baseline-led assessment requires a comprehensive and high quality data basis. Particularly up-to-date information on the state, sensitivity and carrying capacity of LUCCA, more specific spatial effects of climate change at regional level and results from monitoring should be part of a national environmental information system.

At regional level specific spatial data for the past or future time scale should be available in national or regional environmental data catalogues, or should be gathered in the future with a sound effort. The available data should be of an adequate quality to secure the indicators' reproduction and reliance in the assessment. An up-dated environmental baseline requires the amendment of current environmental information systems to regional environmental data profiles, which describe the current and predicted future environmental situation and affected land use within a region. Gained knowledge on spatial effects of climate change should be well integrated into land use planning decisions. For this purpose it is recommended to up-date existent regional environmental or spatial information and data registers with the objective to establish profiles, which contain designated land uses, the current and predicted future status of LUCCA, and the monitoring of spatially-relevant measures for adaptation to climate change. The selected guidance indicators should be linked to regional environmental data and must also be continuously revised in an iterative process, which depends on the relevant environmental objectives and available fit-for-purpose data at regional planning level.

Such profiles have the function to compile all data within a regional planning area on spatially-relevant measures. They can be used to integrate concerns of the adaptive capacity of land uses against negative impacts of climate change and compare region's relative environmental sensitivity, potentials and rank in the adaptation performance. Contents of such a register could be brownfields, areas below a future sea water level, current retention areas designated for river flooding, missing corridors for the connection of wildlife biotopes, recreational areas accessible from densely populated urban areas, future productive areas for agriculture and forestry and compensation areas for lost areas of LUCCA. It will be essential to register zones of cumulative effects, e. g., of precipitation and inundation water leading to potential high flood risks, which should be proposed at the higher regional planning level as a preventive framework for land use planning. The register will ideally be continuously amended with knowledge on regional effects of climate change and monitoring results.

Regional conflict maps from SEA-REP can firstly highlight areas, land uses or environmental components, that are especially sensitive to climate change or which are to be abandoned in the future. Secondly land uses with good potential to mitigate negative effects of climate change and prevent from significant harm of natural disasters can be documented. From these conflict maps action maps and

strategy plans are to be derived.

Applying the SEA-REP+LUCCA Indicator System

A main problem of German regional planning is its strong determination by communal planning and that the precautionary consideration of environmental concerns is generally still weak in comparison to economic considerations. With knowledge on spatial effects of climate change the competent authorities for SEA-REP should promote an improved consideration of environmental concerns in the weighting process, and should voluntarily integrate indicators such as LUCCA to the general SEA assessment process. The motivation to do this is evident with the precaution arising from predicted more frequent and intense negative environmental effects, caused by climate change, and the need to make future land use changes transparent to the public. Results of SEA-REP should ideally be mitigation and adaptation measures for land use change, i.e. the provision and designation of areas for LUCCA 1-12.

Developing a Tiered Decision-Support System

A tiered decision-support system for a more sustainable land management should be implemented and maintained for SEA in land use planning from the national to the communal level. Such a tiered system should include information from SEA processes passed on from one vertical level to another or from sector to regional plan level. This could apply restrictions, taboo zones, minimum distances, impact factors, impact zones. Regional planning should document contents of SEA and further requirements, which are tiered down to binding land use planning. A regional framework can be created with orientation values for settlement densities, population development guidance values, intensity of land use, maximum soil sealing level, guidance values for dense building sites or compensation areas. Areas of general importance need to be assessed in more detail at lower planning and project level, before REP designations are decided or authorisation for project development is given (tiering regulations).

Challenging Conventional Regional Planning

There exists a need in regional planning for a more transparent and focused designation of sites particularly vulnerable or resilient to effects of climate change or with high potentials for mitigation of carbon release. Therefore an area management is required, which is strongly related to future land use potentials and the securing of the allocation of resources. The adaptation process requires a frame for the integration of future climate risks into political decision-making processes at regional level, which again calls for a challenging of traditional regional planning systems in Europe.

Sustainable area management and the provision of land uses of importance for the adaptation to climate change, in combination with a well implemented and efficient natural disaster management, will potentially decrease the risk of loss of human lives and reduce costs and effort in the future. Regional planning should thus introduce new regional plan designations as response to effects of climate change such as:

- priority areas for land uses with superior importance for adaptation to climate change; or
- priority areas for compensation, e.g. open spaces with future potential for recreation, or sealed areas to be desealed.

Regional planning has the advantage of considering cumulative impacts from all integrated sector designations and regional effects of climate change. It is thus recommended to amend regional plan

contents, if adequate. Conventional designation criteria should be challenged on their conflicts with principles of precaution and adaptation strategies for a changing climate.

Beside strict EU or national legislations or economic incentives and calculations of future ecological or social costs, the motivation of RPB to initiate action for adaptation to climate change may be influenced by public concerns about negative predictions of climate change effects. In the contrary, scientific predictions of positive environmental, economic and social effects of climate change in certain European areas could be demotivating. Therefore environmental targets will have to be more carefully weighted with economic and social concerns. The political willingness to initiate changes of land use shall be further motivated by knowledge exchange and transborder recommendations for the adaptation of regional land use to climate change. SEA-REP+LUCCA can function as a driving force for RPB to commit to voluntary actions for the adaptation to impacts of climate change and to implement spatially-relevant measures and actions to avoid land consumption, land use change, fragmentation, groundwater depletion and flooding.

A problem of binding set targets for voluntary self-commitments of a RPB is, that the stage, when a certain target of self-commitment is reconciled with a set environmental target, can often hardly be defined. Preconditions for an adequate evaluation is information on tolerable environmental impacts of REP contents and the contribution of identified polluters to the achievement of a certain target. RPB would agree on commitments, but not represent the collectivity of all sources of impacts.

In the future, regional planning can and should deliver important contributions to a sustainable regional development, not only with its functions for cross-section coordination and mediation, but with the introduction of new strategies for the reduction of land degradation and for the adaptation to climate change. In this context the rather weak institutionalisation of the regional level can even become an advantage, as the initiation and mediation of innovative approaches, e.g. through cooperation, cannot be achieved in conventional static structures.

Improving Cooperation with Sector Planning

In the context of climate change a dynamic area management, which cuts across all sectors and can be modified according to emerging needs and contexts, will be increasingly important. In order to achieve common regional visions and strategies, all actors involved in land use planning should deliver objectives and requirements for a sustainable regional planning adapted to climate change. SEA-REP has the potential to be an incentive to improve cooperation and establish cross-sectoral regional adaptation strategies. Improved communication and cooperation between sector and spatial planning is recognised to be an indispensable component of efficient regional plan-making, if fast, dynamic and efficient actions for adaptation to climate change shall be achieved.

The sustainable use of water resources, agricultural and forested land is very closely linked to lively rural societies and socio-economic conditions of European rural areas. All sectoral departments should determine vulnerability zones of flooding, droughts and fire risk, storms and wind-damage, should identify regional variations in rates of change and derive requirements for spatial adaptation. A sooner adaptation to climate change will require a partial extensification of land management of agriculture and forestry and a higher weight of ecological concerns in land use planning.

Landscape planning needs to clarify its responsibilities for contributing to long-term achievements of regional adaptation objectives. Its procedural elements, which are directly linked to the SEA-REP process,

should be strengthened and its objectives and area designations should be well integrated into regional planning in the weighting process, if the aim is to effectively implement LUCCA. Regional planning and nature conservation bodies should take over increasing responsibility to voluntarily initiate round tables with other sector plan authorities beyond legally required SEA-REP scoping meetings, in order to set common targets for adaptation of the region's area management to climate change. An ecological tendency of regional planning demands consistent concepts, which feature a high level of sectoral assignments. A core measure will be the determination of priorities, which should be uniformly weighted and commonly accepted.

In Germany a future landscape framework planning (LRP) will require higher actuality and target-oriented amendment of plans in line with SEA-REP. Currently, LRP does not sufficiently implement national climate protection objectives and objectives for the adaptation of humans, species and habitats to climate change. Beside the conventional deliverance of contributions in form of conflicts, objectives and assessment thresholds for nature conservation, species and biotope protection, LRP should develop problem-specific modules for adaptation and mitigation measures of climate change, which could include future tasks of:

- an area-wide assessment of the vulnerability of natural area potentials (e.g. areas affected by rising sea levels, high level soil degradation or land consumption, ongoing fragmentation, high aridity or river flood) and the formulation of future objectives for their maintenance or even abandonment of current land uses;
- an area-wide assessment of the suitability of natural area potentials for the mitigation of negative impacts of climate change with the purpose of designation of priority areas in the regional plan (e.g. the ecological upgrading and extension of woodlands, wetlands and grasslands);
- objectives for a stricter protection of LUCCA with superior and general importance against physical degradation and the implementation of mitigation and adaptation measures;
- the supply of a regional and sub-regional area-wide ecological spatial structure for the presentation of functionally connected complexes and for the collection of data about functional interrelations between natural areas as ecological landscape units.

Involving the Public in the Development of Adaptation Strategies

Beside a political and legal basis for adaptation to climate change, it will be important in the EU to find coherent ways to regulate and adjust the behaviour of national and regional populations. Therefore a change of behaviour patterns should be promoted by informing and involving the public in the development of adaptation strategies. SEA-REP cannot only contribute to a stronger awareness of the scarcity of resources, but also to a higher evaluation of natural resources within a society that is dependent on the functionality of the natural capacity. It is recommended to systematically involve the public particularly in decisions of regional area management with long-term consequences on the regional quality of living, human health and well-being. SEA-REP is deemed to be an adequate decision-aiding system, which can be coupled with the administrative securing of public participation in target setting. If the public is well involved in the setting of regional environmental targets, a certain future decrease of the living quality in the region is more likely accepted. The realisation of a lasting sustainable development in society and policy demands a continuous up-dating of the environmental awareness in all generations. In the context of likely negative effects of climate change on future generations awareness is not sufficient as yet. It will probably increase with direct consequences for the population such as loss of coastal areas to sea level rise, relocation of settlements or an accepted higher risk of flooding.

The higher the public awareness of links between land use planning, predicted negative effects of climate change and mitigation or adaptation measures, the higher the incentive for and willingness of politicians to set national objectives for stricter protection of the land and natural resources. With an SEA-REP process that is accepted by stakeholders and the public, more likely a long-term optimisation of regional land use planning in terms of improved integration of environmental concerns, integrated adaptation measures to climate change and mitigations of adverse effects of regional development will be achieved. SEA-REP should contribute through transborder consultation and public participation to transparency and raising of public awareness. Current processes will further have to be improved with increasing expertise gained in practice.

6.3 Future Research Needs and Outlook

Operationalisation and Application in Practice

Before its application in practice the LUCCA indicator system will have to be adapted and modified for the specific environmental conditions and baseline data in the different EU regions. The challenge will be to develop regional-specific adaptation strategies. The proposed list of state and impact indicators is not exhaustive, but has to be extended and modified for each specific EU region, depended on the REP contents and their likely significant impacts and predictions of regional impacts of climate change. The indicator system does not replace a general SEA-REP considering all environmental media in a region. The use of the formal process of SEA-REP in combination with informal regional management tools to improve the decision-support framework for the protection of the natural resources and the land against ongoing degradation at project level will have to be tested in practice.

Data and Research Needs

The application of the LUCCA indicators in practice in several case studies will be carried out under high uncertainty of predictions of spatial effects of climate change and a consideration of the time delay of implementations. Further research will be necessary on the integration of the environmental potential of land uses for the capture and storage of carbon into SEA-REP. Vulnerability assessments of all environmental components in a region, including LUCCA, will be useful.

National strategies for the adaptation to climate change of the EC Member States will require clear objectives and responsibilities for monitoring, outsourcing of tasks and consultation, which will result in an increasing importance of methods for the acceleration of the process. National adaptation strategies will require:

- improved understanding of possible emission pathways and their effects on the climate;
- more specific predictions of spatial effects of climate change;
- assessment of adaptive capacity of natural resources and land uses;
- sector-specific investigations of possible strategies;
- improved information systems.

Monitoring and Quality Review

In SEA-REP practice, the difficulties of the applied SEA methodology should be examined in the future

in sufficient detail, in order to provide a good guidance for future SEA-REP. A quality review of the proposed SEA-REP assessment method with the objective of an evaluation of the viability of the proposed LUCCA indicators and effect of SEA-REP on the optimisation of the regional plan and the process of awareness and behavioural change among practitioners, authorities and the public will be necessary. The integrity and credibility of the assessment of impacts on LUCCA requires external scrutiny of a quality review of an independent body of experts. At EU policy level monitoring results of SEA-REP can be used as a barometer of the adaptation tendency of land uses in the EU Member States' regions.

Economic Incentives

The implementation of adaptation measures at national and regional scale shall not fail due to investment obstacles or insufficient personal capacity at responsible authorities. Beside information, taxes and environmental labelling can be useful policy instruments for achieving the target. Sufficient finances could include financial incentives and certificates for voluntary self-commitments of the regions to strive for a conscious and justified decision-making in the context of climate change. Higher costs of SEA-REP, due to the integration of LUCCA, are justified, as costs of management of adverse impacts of climate change and natural disasters and catastrophes tend to be reduced. Economic incentives for a stricter integrating of mitigation and adaptation measures into land use planning could be ecological labels or certificates, which are awarded to EU regions with the "best process and achievements of objectives for adaptation to climate change", i.e. overall low conflict intensities with LUCCA. The environmental media of human health, biodiversity, soil, water, air and climate are of special relevance for adaptation of land use to climate change, but most of them have no economic price and need to gain further attention in EU and national environmental policy. Financial support could also function as driving force for the development of new policies and the setting of regional quantitative environmental objectives for the protection of the land against physical degradation.

Sustainability Impact Assessment

In the long term German SEA-REP will develop into an integrated assessment or sustainability impact assessment, because of important spatially-relevant economic and socio-cultural dimensions of effects of climate change, such as location of residents, agricultural business structures, renewable energy demand and supply, population structure, migration and demography, traffic and commuting, housing and local services supply and quality of life. Climate change will cause negative and positive effects on the region's economy and societies in the same way as on the environment. There are also strong links and interrelations between ecological and social aspects, for instance between human health, climate/air and recreation. Social indicators relevant for SEA-REP would be for instance 'the protection of the population in designated flood areas' or 'socio-economic impacts of afforestation or conversion of agricultural land'. Therefore it is likely that the German SEA-REP with a current emphasis on environmental impacts will evolve into an extended sustainability impact assessment. This would enhance the justification of future costs in front of the public. All standards for decision-making are linked to costs of preventive and reactive actions, which must be compared with benefits. For example, in order to set a threshold for how much land consumption in a region shall be tolerated, it must be defined what the value of a reduction of soil sealing is and what the costs of such a reduction are. However, it should be guaranteed that in SEA-REP environmental consequences are at least addressed with as much attention as economic consequences. Significant impacts on LUCCA shall gain special attention in the regional weighting

process, as natural conditions of the land promises a higher resistance to risks of future damage and a higher adaptability to changes of the state of the environment. It is then supposed that SEA-REP has the potential to contribute to changing actions or ideas of decision-making in adaptation to climate change.

Outlook

It will finally depend on the political willingness of the states and regional planning authorities, whether to use this potential for an urgent and soon adaptation of regional land uses to climate change and the mitigation of negative impacts on natural resources. The long time span between objectives for adaptation at regional plan level and their implementation in practice demands a walk of the talk starting today.

Finally, it is important to bear in mind, that climate change is a global problem, which must be adapted to world-wide at all planning levels and in all sectors with a variety of different strategies and approaches. For instance tropical rainforests are crucial for the world-wide climate system and water supply for many neighbouring regions. Important target regions for adaptation actions will be vulnerable regions in developing countries. Social impacts of water scarcity and migration of people will influence regions future visions worldwide. Poor drinking water and food quality in developing countries will force many people to leave their homes and migrate to other countries, including EU countries. Therefore knowledge exchange and projects are needed at regional level with specific objectives for the implementation of adaptation and mitigation strategies in developing countries. Not always a compromise between proposed adaptation measures and current environmental visions for the regional state of environment in the natural, cultural and historical context of the area will be found. It is likely, that a future priority will have to be set more often with adaptation goals, than with the safeguarding of cultural or historic values of the past such as anthropogenic coastlines.

7. Annex

Table A1: Proposal for the integration of SEA into the regional plan-making process of Saxony

(Source: Stratmann et al. 2007a)

Procedural Steps of Regional Planning (according to Saxon Land Use Planning Act, [SächsLPlG])	**Procedural Steps of SEA (according to ROG, UVPG, Saxon EIA Act [SächsUIG])**	**Integrated Participation of Authorities and the Public (Regional Planning and SEA)**
Plan-making decision	Monitoring (Art. 12 SächsUIG)	Public announcement of the ordinance decision and results of monitoring
Participation in plan-making (preliminary draft plan) (Art. 6 para. 1 SächsLPlG)	Screening (Art. 7 para. 5 No. 5-7 ROG)	Participation of authorities: Transmission of the preliminary draft plan to the parties of concern, including the neighbouring states. Transmission of the preliminary draft plan, including the draft of the scope of SEA, to the environmental authorities for their statements (if applicable also to the competent authorities of neighbouring states)
	Scoping (Art. 7 para. 5 No. 4 ROG)	
Public hearing (draft plan) (Art. 6 para. 2 SächsLPlG, Art. 6 para. 3 SächsLPlG, Art. 6 para. 4 SächsLPlG)	Environmental Report (Art. 7 para. 5 ROG)	Public participation Written announcement and Transmission of the draft plan together with the environmental report to the the parties of concern for their statements, including neighbouring states Public announcement and display of the draft plan and environmental report for statements of the public (if applicable also in concerned neighbouring states) If required enforcement of oral consultations (if applicable also in concerned neighbouring states)
	Participation of authorities (Art. 7 para. 6 ROG)	
	Public participation (Art. 7 para. 6 ROG)	
	Transboder Participation (Art. 7 para. 6 ROG in combination with Art. 14 j UVPG)	
	Decision-making (Art. 7 para. 7 No. 3 ROG)	
Decision on releasing regional plan as ordinance (Art 7 para. 2-4 SächsLPlG)	Summarising declaration (Art. 7 para. 7 No. 8 ROG)	Public Announcement of the decision and public display of the final plan, environmental report and summarising declaration. If applicable transmission of the plan and environmental report including the summarising declaration to concerned neighbouring states.
	Announcement of decision (Art. 7 para. 9 ROG in combination with Art. 14 j, l UVPG)	
	Monitoring (Art. 7 para. 10 ROG)	

Table A2: Matrix of impact zones in relation to regional plan contents and environmental components

Environmental Component / Site-specific Regional Plan Contents	Human		Fauna/Flora/ Biodiversity					Soil						Groundwater				Surface water				Climate/ Air		Landscape				Cultural/ material assets	
	HH 1) Noise pollution in settlement areas	HH 2) Pollution in settlement areas	FFB 1) Biotope types and habitats	FFB 2) Protected species	FFB 3) Biotope connection network	FFB 4) Protected areas	FFB 5) SAC areas and SPA	So 1) Natural productivity	So 2) Storage and regulation function	So 3) Biotic habitat function	So 4) Erosion risk	So 5) Contaminated soils	So 6) Unsealed areas	Gw 1) Groundwater development rate	Gw 2) Protection of Groundwater against pollution	Gw 3) Groundwater level below ground	Gw 4) Drinking water catchment areas	Wa 1) Biological structure of rivers and streams	Wa 2) Floodplains and retention areas	Wa 3) Water quality of rivers and streams	Wa 4) Barrierless flow of rivers and streams	AC 1) Bio-climatic condition	AC 2) Highly polluted areas	La 1) Landscape character	La 2) Areas for recreation in proximity of central places	La 3) Unfragmented areas	La 4) Protected areas for recreation and open areas in need for protection against noise	Cu 1) Constructed cultural and material assets, monuments	Cu 2) Landscapes, their elements and soils with archive function
Priority or reserve area for measures of technical flood protection	—	—	**1000**	1000	—	**3000**	**3000**	100	—	—	—	100	—	300	—	300	**3000**	1000	**3000**	—	—	—	—	300	300	—	**3000**	**3000**	**1000**
Priority or reserve area for the use of local non-renewable resources	**5000**	**5000**	—	300	—	**3000**	**3000**	100	—	—	—	—	—	—	100	100	**1000**	1000	**1000**	100	—	500	500	300	300	—	**5000**	**3000**	**1000**
Priority or reserve area for afforestation	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	300	—	—	—	—	—
Wind energy production sites	**5000**	—	**2000**	60000	—	**5000**	**15000**	—	—	—	—	—	—	—	—	—	—	5000	**5000**	—	—	—	—	5000	5000	—	**5000**	**3000**	**1000**
Priority or reserve area for water resources	—	—	**5000**	5000	—	**5000**	**5000**	—	—	—	—	10000	—	10000	—	10000	—	5000	**10000**	—	—	—	—	—	—	—	—	—	—

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Urban development sites	—	—	—	100	—	**300**	**300**	—	—	—	—	—	—	—	100	100	**100**	—	—	—	—	100	—	300	100	—	**100**	**300**	**100**
Industrial and commercial sites	**300**	**300**	**300**	300	—	**300**	**1000**	100	—	—	—	100	—	—	100	100	**100**	100	100	100	—	300	300	300	300	—	**300**	**300**	**100**
Tourism sites	**300**	**300**	**300**	300	—	**300**	**300**	—	—	—	—	100	—	—	100	100	**100**	100	100	100	—	100	100	300	300	—	**300**	**300**	**100**
Use of water bodies for recreation or sport	—	—	—	300	—	**300**	**300**	—	—	—	—	100	—	—	—	—	—	—	—	—	—	—	—	300	300	—	**300**	**100**	**100**
Securing of transport routes/corridores: - Country road (<= 10.000 vehicles/d)	**800**	**200**	**800**	500	—	**800**	**800**	200	200	200	—	—	—	—	100	100	**100**	100	100	100	—	100	100	300	800	—	**800**	**100**	**100**

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- Federal road (> 10.000-50.000 vehicles/d)	**1 5 0 0 0**	**2 0 0 0**	**3 0 0 0**	1 5 0 0 0	—	**1 5 0 0 0**	**1 5 0 0 0**	2 0 0 0	2 0 0 0	2 0 0 0	—	—	—	—	3 0 0 0	3 0 0 0	3 0 0 0	3 0 0 0	3 0 0 0	3 0 0 0	—	3 0 0 0	3 0 0 0	5 0 0 0	1 5 0 0 0	—	**1 5 0 0 0**	**1 0 0 0**	**1 0 0 0**
- Motorways (> 50.000 vehicles/d)	**3 0 0 0 0**	**2 0 0 0**	**5 0 0 0**	3 0 0 0 0	—	**3 0 0 0 0**	**3 0 0 0 0**	2 0 0 0	2 0 0 0	2 0 0 0	—	—	—	—	5 0 0 0	5 0 0 0	5 0 0 0	5 0 0 0	5 0 0 0	5 0 0 0	—	5 0 0 0	5 0 0 0	1 0 0 0 0	3 0 0 0 0	—	**3 0 0 0 0**	**1 0 0 0**	**1 0 0 0**
Transborder use of Polish airspace for air traffic	**3 0 0 0**	**3 0 0 0**	—	3 0 0 0	—	**3 0 0 0**	**3 0 0 0**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3 0 0 0	3 0 0 0	—	3 0 0 0	—	**3 0 0 0**	—	—
Recreation at water bodies after abstraction of near-surface resources	**1 0 0 0**	—	—	1 0 0 0	—	**1 0 0 0**	**1 0 0 0**	—	—	—	—	—	—	—	—	—	**1 0 0 0**	—	—	—	—	—	—	1 0 0 0	1 0 0 0	—	**1 0 0 0**	—	—
Use of a former pit for the extension of an industrial infill	**1 0 0 0**	**1 0 0 0**	**1 0 0 0**	1 0 0 0	—	**1 0 0 0**	**1 0 0 0**	1 0 0 0	1 0 0 0	1 0 0 0	—	1 0 0 0	—	—	1 0 0 0	1 0 0 0	**1 0 0 0**	1 0 0 0	**1 0 0 0**	1 0 0 0	—	1 0 0 0	1 0 0 0	1 0 0 0	1 0 0 0	—	**1 0 0 0**	**1 0 0 0**	**1 0 0 0**

Table A2: Matrix of impact zones in relation to regional plan contents and environmental components

Environmental Component / Site-specific Regional Plan Contents	Human		Fauna/Flora/ Biodiversity					Soil						Groundwater				Surface water				Climate/ Air		Landscape				Cultural/ material assets	
	HH 1) Noise pollution in settlement areas	HH 2) Pollution in settlement areas	FFB 1) Biotope types and habitats	FFB 2) Protected species	FFB 3) Biotope connection network	FFB 4) Protected areas	FFB 5) SAC areas and SPA	So 1) Natural productivity	So 2) Storage and regulation function	So 3) Biotic habitat function	So 4) Erosion risk	So 5) Contaminated soils	So 6) Unsealed areas	Gw 1) Groundwater development rate	Gw 2) Protection of Groundwater against pollution	Gw 3) Groundwater level below ground	Gw 4) Drinking water catchment areas	Wa 1) Biological structure of rivers and streams	Wa 2) Floodplains and retention areas	Wa 3) Water quality of rivers and streams	Wa 4) Barrierless flow of rivers and streams	AC 1) Bio-climatic condition	AC 2) Highly polluted areas	La 1) Landscape character	La 2) Areas for recreation in proximity of central places	La 3) Unfragmented areas	La 4) Protected areas for recreation and open areas in need for protection against noise	Cu 1) Constructed cultural and material assets, monuments	Cu 2) Landscapes, their elements and soils with archive function
Special air field	**300**	**300**	**300**	300	—	**300**	**300**	300	300	300	—	300	—	—	—	300	**300**	300	**300**	—	—	100	100	300	300	—	**300**	**100**	**100**
Priority area for above ground electrical power supply line (110-kV)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2000	2000	—	**2000**	**3000**	**1000**

500 **Restriction** (Potentially strong legal connection of the environmental compotent): impact zone in [m]

300 **Conflict** (Conflict intensity in dependence of the assessed value of the environmental component and the impact factor): impact zone in

8. Lists of Figures, Tables and Boxes

8.1 Figures

8.2 Tables

8.3 Boxes

9. Bibliography

9.1 Literature

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9.2 Legislations, Norms and Regulations

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WHG – Federal Water Management Act in the version of 19.08.2002, Fed. Law Gazette I, p. 3245.

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